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The Intertidal Fauna of Sandy Beaches - A Survey of the East Scottish Coast

Scottish Fisheries Research
Report Number 38 1988
ISSN 0308 8022

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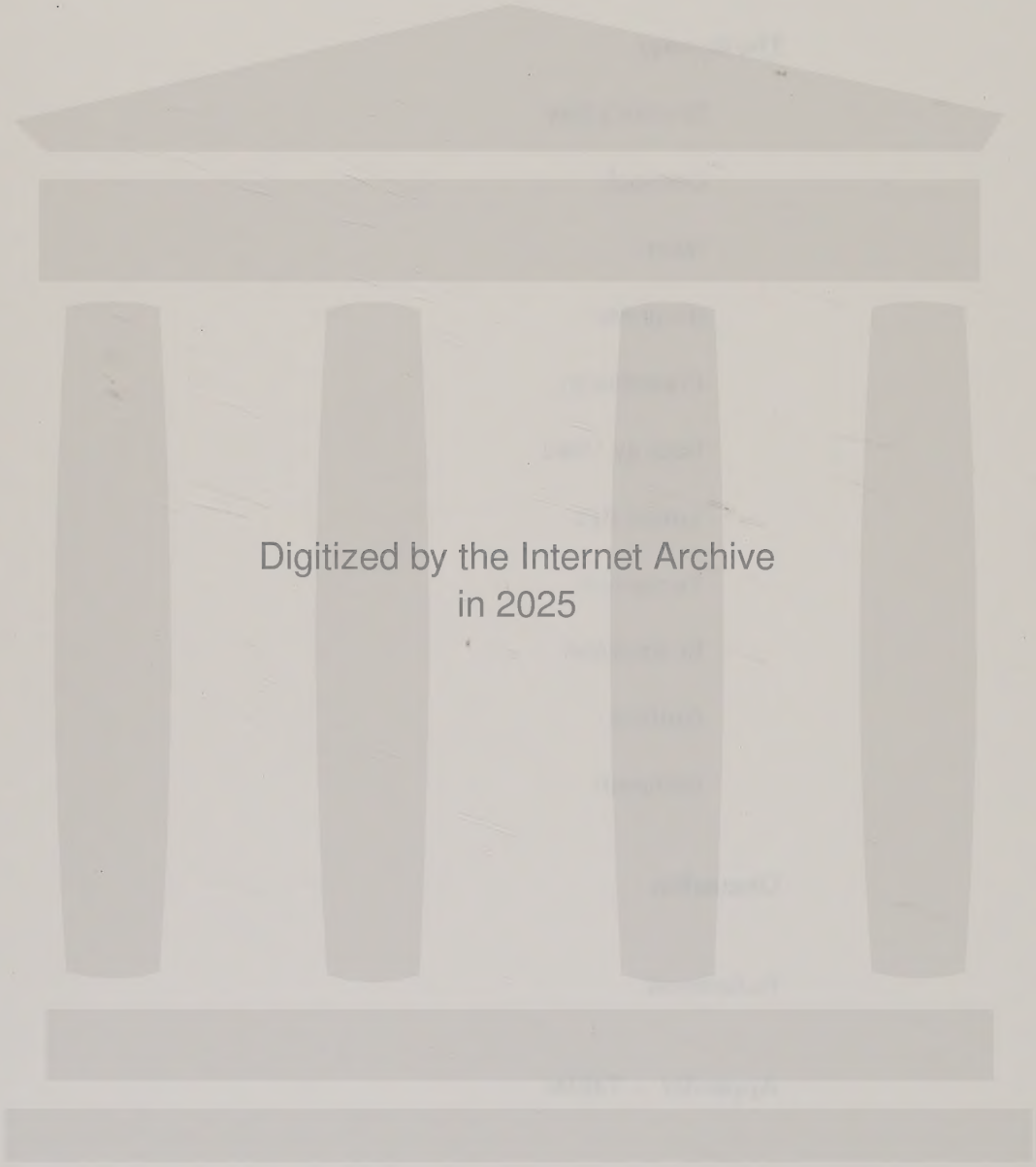

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The Intertidal Fauna of Sandy Beaches - A Survey of the East Scottish Coast

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Introduction

The sandy intertidal areas around the Scottish coast constitute important nursery grounds for flatfish, of which the plaice *Pleuronectes platessa* (L.) is the most important species. Studies on the distribution of young plaice have revealed that the young fish, during their first year of benthic life, concentrate their feeding on the tidal flats (Edwards and Steele 1968; Kuipers, 1977). A first attempt to assess the importance of these feeding grounds, by describing the abundance and biomass of the food organisms, was made in the early 1970s (Eleftheriou and McIntyre, 1976) in a number of selected beaches on the north and west Scottish coasts and in the Outer Hebrides. However the work would have remained incomplete without the inclusion of the east coast Scottish beaches. The present paper reports on the results of the second part of this investigation, which aims to describe the range of variation of the fauna of the east coast beaches and investigate further the underlying causes of the observed variations (Eleftheriou and Nicholson, 1975).

Previous work on the east coast beaches includes a number of faunistic collections (Scott, 1887; Elmhirst, 1931; Raitt, 1937; McKay and Smith, 1979) and a limited number of general surveys of a quantitative or semi-quantitative nature. Stephen (1920, 1929, 1930) surveyed the fauna of a number of beaches in the Moray Firth, the Aberdeenshire coast, the Fife coast and the Firth of Forth, and Scott (1958) concentrated on the beaches of the Aberdeenshire coast. Clark, Alder and McIntyre (1962) investigated the distribution of *Nephtys* and the associated fauna on many sediment shores including those on the east coast. Several detailed surveys of the fauna of inner firths and inlets are also available (Wells and Boyle, 1973, 1974, 1975; Bartrop, Bishop, Harvey, Holme, Knight and Powell, 1980) for the sediment beaches of the east coast.

As most of these works refer to areas affected to some degree with dilution by fresh water and by pollution, they are not directly relevant to the purpose of this report, which concentrates on relatively clean open oceanic beaches; mention is made of them, however, whenever appropriate.

Methods

On each beach, after initial observations were made on the structure, degree of exposure, and the position of any fresh water inflow noted, a simple surveying technique was used to construct profiles measured from a suitable bench mark.

Main stations were placed at the estimated levels for high, mid and low tide along the profile transect, with intermediate stations also being inserted; the numbers of these depended on the width of the interidal zone.

At each station one quadrat of 1/16 m^2 was dug for macrofauna and the sand sieved through a 0.5 mm mesh, the residue being preserved in 5% formalin. On return to the Laboratory, all animals were identified and counted and the wet weight was measured after drying on laboratory tissue. Dry weights were calculated using conversion factors. Cores for meiofauna were also collected but have not yet been analysed.

Sediment samples for carbon and chlorophyll estimation were collected by means of 2.2 cm internal diameter core tubes. The samples were divided into 2 cm fractions and stored deep-frozen.

The organic carbon content was determined using an adaptation of the wet oxidation technique described by Strickland and Parsons (1972), where 0.1–1.0 g sediment was analysed instead of the filter paper used in water analysis. The top 2 cm of similar subsamples of sediment was analysed for chlorophyll a. This technique is a modification of that outlined by Strickland and Parsons (1972), in which the pigments are extracted with 90% acetone. Additional sediment samples were collected by means of 4.4 cm core tubes for particle size determination. The sediment was preserved with 60% alcohol and analysed in the Laboratory by dry sieving of the sand fraction (McIntyre and Murison, 1973). The sorting coefficients and median diameters were calculated and the cumulative curves constructed from the results. Measurements were also made on the salinity and temperature of interstitial water.

The sampling strategy adopted for the present work was as described by Eleftheriou and McIntyre (1976).

The surveys were spread over several years (1977–1981) and were conducted on spring tides during the period of July to October. Nevertheless it is to be expected that differences in the timing of sampling might be responsible for variations not only in the faunal composition but also in the density and biomass of the different beaches. However as there is some long term constancy in the prevailing conditions in the coastal environment, sudden and spectacular changes in the populations are rather unusual and therefore do not seriously affect the validity of the faunistic comparisons between the different beaches.

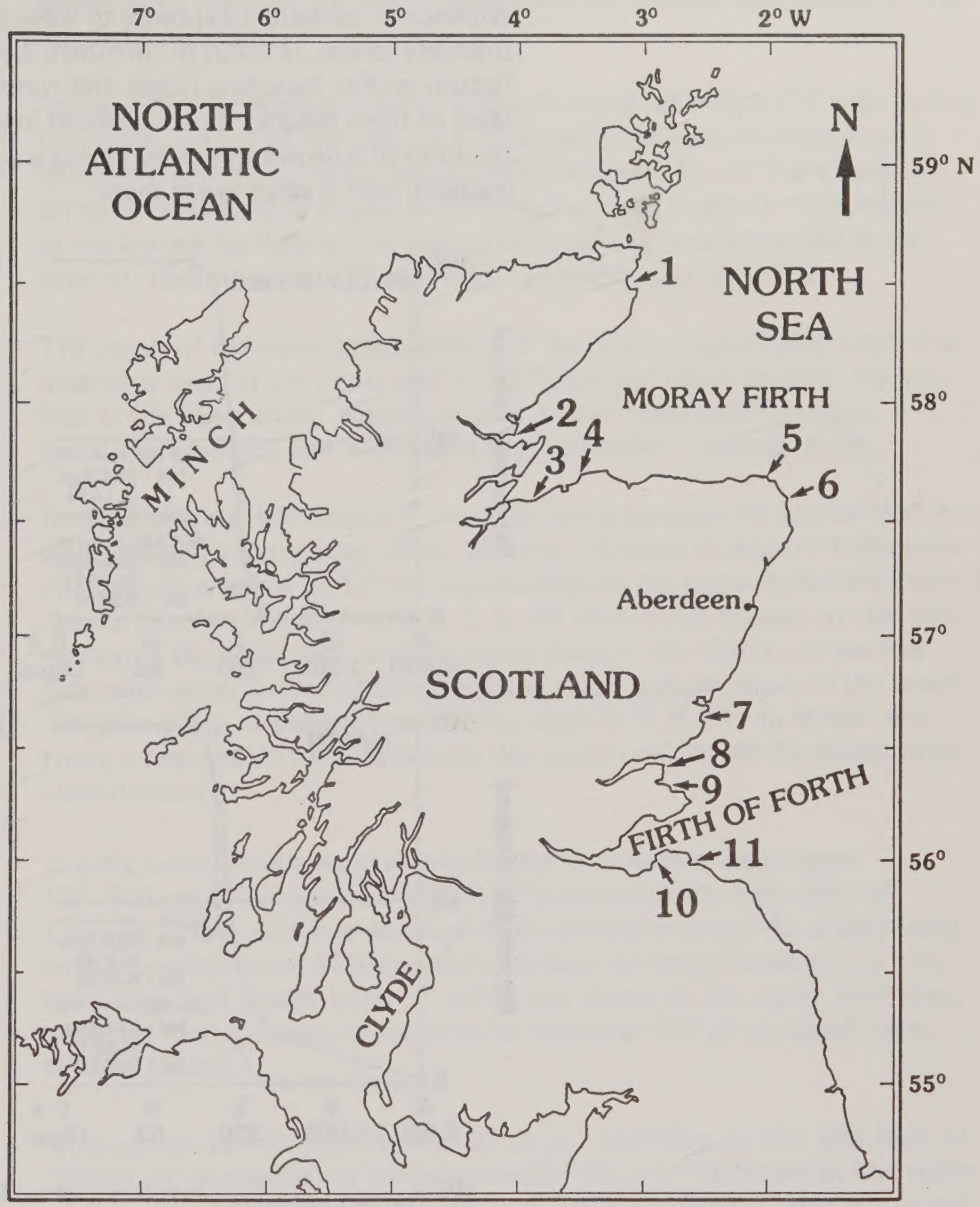
The Habitat

The 11 selected sandy beaches, located on the east Scottish coast (Fig. 1), were the following:

1. Sinclair's Bay
2. Dornoch
3. Nairn
4. Burghead
5. Fraserburgh Bay
6. Rattray Head
7. Lunan Bay
8. Tentsmuir
9. St Andrews: West Sands
10. Gullane Bay
11. Belhaven

The east coast is intersected by a number of firths but overall it is uncomplicated, without any indentations or island formations. The beaches, located from just south of Duncansby Head to the outer reaches of the Firth of Forth, face the open North Sea and have an orientation within the north to east sector. The nature of the coastline varies with extensive sandy stretches in the Moray Firth (beach numbers 3, 4), the Aberdeenshire coast (number 6) and the Fife coast (numbers 8, 9) while the remaining coastline is predominantly rocky, interspersed with a number of moderate to large sandy bays (numbers 1, 2, 5, 7, 10, 11). The beaches are exposed to winds from the east

and north-east and swell from the north but are not affected by the prevailing offshore north-easterly winds. Long shore currents affect much of the coast, especially those beaches along the north and north-east coasts of Scotland and also along the Fife coast (numbers 1, 6, 7).



1 Sinclair Bay	5 Fraserburgh	9 St Andrews
2 Dornoch	6 Rattray Head	10 Gullane
3 Nairn	7 Lunan Bay	11 Belhaven
4 Burghead	8 Tentsmuir	

Figure 1. Map showing location of sampled beaches.

Because of its simple morphology the east Scottish coast is relatively exposed. The exposure spectrum is narrower than that observed in the north and west Scottish beaches (Eleftheriou and McIntyre, 1976). Nevertheless those beaches which are recessed along the coastline at the outer parts of large Firths do receive greater shelter from northerly winds and swell.

The 11 sites described in this report are representative of the range of the intertidal sediment environment encountered on the east coast of Scotland. Appendix Table I provides information on each beach as to the number and position of the stations in relation to the tidal levels, with details on the physical and chemical characteristics of the sedimentary environment at the period of sampling.

The tides on the east coast of Scotland are semi-diurnal with overall small diurnal inequality. The mean tidal range is 2.2–4.5 m with a mean of 3.4 m. The beaches are roughly separated into those which are relatively short, ie 100–120 m with a smooth but steep gradient (numbers 1, 2, 5, 6) giving evidence of consistent exposure to wave action, and those which are considerably longer, ie >200 m (numbers 3, 4, 7, 8, 9, 10, 11) with an irregular flattish profile including ridges and runnels and a steep upper foreshore. Most of these beaches show a marked irregularity around MLWN, either in the form of a depression or by having a sudden and abrupt change in the gradient, with a steep lower shore.

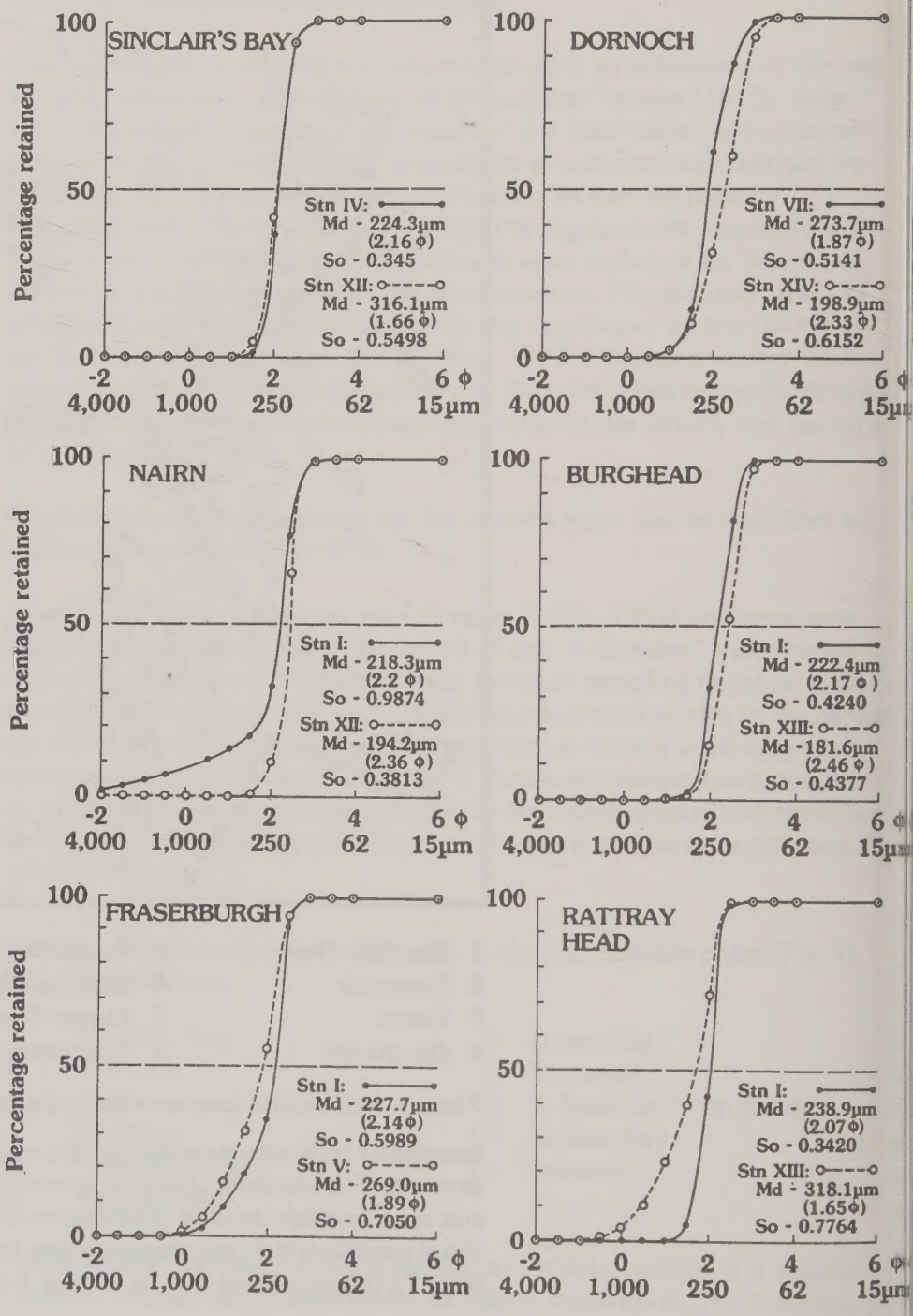

Percentage retained
SINCLAIR'S BAY
Stn IV: Md - 224.3µm (2.16 ϕ) So - 0.345
Stn XII: Md - 316.1µm (1.66 ϕ) So - 0.5498
DORNOCH
Stn VII: Md - 273.7µm (1.87 ϕ) So - 0.5141
Stn XIV: Md - 198.9µm (2.33 ϕ) So - 0.6152
NAIRN
Stn I: Md - 218.3µm (2.2 ϕ) So - 0.9874
Stn XII: Md - 194.2µm (2.36 ϕ) So - 0.3813
BURGHEAD
Stn I: Md - 222.4µm (2.17 ϕ) So - 0.4240
Stn XIII: Md -181.6µm (2.46 ϕ) So - 0.4377
FRASERBURGH
Stn I: Md - 227.7µm (2.14ϕ) So - 0.5989
Stn V: Md - 269.0µm (1.89ϕ) So - 0.7050
RATTRAY HEAD
Stn I: Md - 238.9µm (2.07ϕ) So - 0.3420
Stn XIII: Md - 318.1µm (1.65ϕ) So - 0.7764
100
50
0
-2 0 2 4 6 ϕ
4,000 1,000 250 62 15µm

Figure 2. Cumulative curves of particle size.

At most locations the grades are well to moderately well sorted. The sediments of a small number of beaches (numbers 1, 9) are very well sorted while in others (numbers 10, 11) the grades are poorly sorted. There is evidence of some vertical grain size stratification and sorting with the surface grades being the finer and better sorted and the coarser fractions occurring below 12 cm depth.

Temperatures of the top 2 cm of sediment never fall below 5°C even during the cooler period of the year, and although temperatures range mainly between 6 and 14°C, higher but localised values of 15–22°C are recorded on some beaches after exposure to strong sunlight (Table I). Nevertheless, as the low spring tides on the east coast occur in the morning and in the evening, temperatures of the interidal sediments tend to be low.

The depth of the water table varies with the beach gradient and relief. It is invariably deep at the upper part of the beach but it can come to the surface at the lower shore. Ripples and runnels on some beaches retain quantities of water, and large pools occur on others (numbers 3, 8).

Interstitial water salinities at 5 cm depth range between 30 and 35°/oo (sea water salinity ranges from 34 to 35°/oo), although in areas of fresh water run-off values as low as 12°/oo are recorded on the upper foreshore (Table I) Several beaches (numbers 1, 2, 4, 6, 8, 10) show some dilution at the intersection of the water table and the beach slope in the vicinity of the mid tide, with some further recurrence at the lower and wet levels of the beach. The proximity of certain beaches (numbers 4, 5, 8, 11) to stream and rivers is responsible for a noticeable decrease in salinity of the lowest intertidal stations.

Organic carbon levels are generally found to be within the range of 173–606 $\mu g\ g^{-1}$ sediment (Table I). The exceptionally high value of 1,415 μg^{-1} sed., which is recorded in Burghhead (number 4), is associated with the outcropping of peat which is present at several levels of the intertidal area. The lowest levels of carbon are found at the upper foreshore, while the highest levels are recorded in the lower half of the beach from MTL to MLWS.

Chlorophyll values range from 0.03 $\mu g\ g^{-1}$ sediment at mid tide level of Tentsmuir (number 8) to a maximum of 4.99 $\mu g\ g^{-1}$ sediment at low water of Fraserburgh (number 5). Normally the highest pigment levels are found between mid tide and low water, with the lowest levels being recorded from the upper half of most beaches and in particular around MHWS (Table I).

The median diameter of the sediment is found to be within the range of 139.4–412.0 μm, apart from isolated pockets of coarser material (Fig. 2). The finest particles are normally found on the lower parts of the beaches visited and the coarser fraction towards the high water mark. At some locations, very coarse grades (up to 796 μm) are present at the MHWS-MHWN level. Despite the fact that the median diameter values of the sediments of the different beaches fall within narrow limits, nevertheless one can distinguish a group of the inner located beaches (numbers 4, 5, 8, 9, 10) with a lower limit consistently set at <200 μm (range 237–149 μm) and a group of the outer beaches with grades predominantly >200 μm, some being as coarse as 384 μm (range 384–216 μm). Though the silt clay fraction is negligible (<1%), variable amounts are present on most beaches.

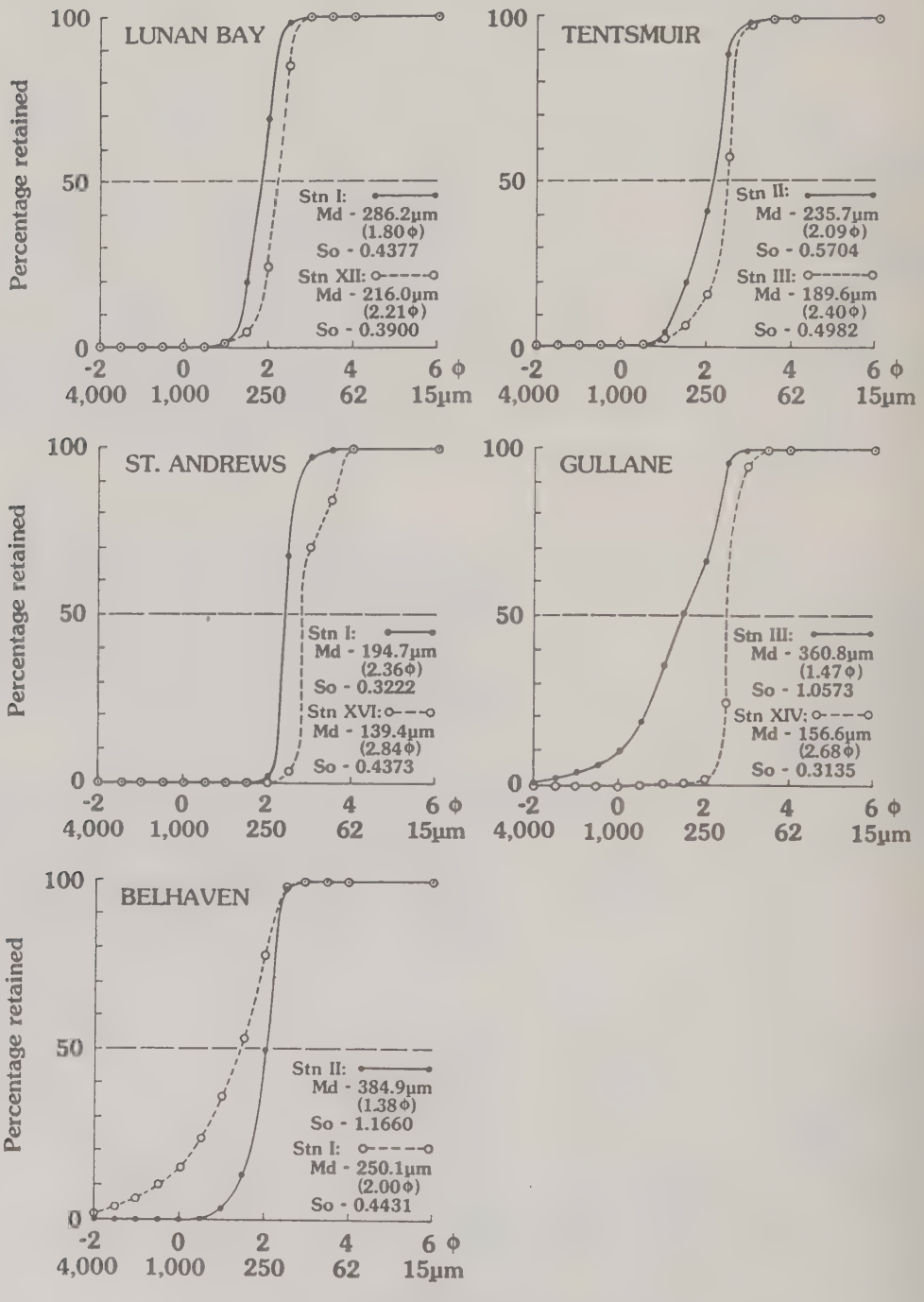


Figure 2. Contd.

1. Sinclair's Bay (Fig. 3)

Physical features

This large bay, lying approximately 5 km north of Wick, is approximately 5 km long with a broad opening, and although oceanic swell enters the Bay, most of the energy is dissipated in the shallow subtidal. The beach is long and narrow and consists mostly of sand and patches of shingle. Glacial deposits in the vicinity of the beach play an important role in the supply of materials to the beach, which is also fed by redistribution of the subtidal sediments. In common with other beaches in the north of Scotland (Eleftheriou and McIntyre, 1976), the short berm (an accumulation of sand above high tide) forms a continuation of the dune system and the marshy backshore. A sizeable stream, the Burn of Lyth, enters the beach at the centre of the Bay, recirculating sand which has been blown inland (Ritchie and Mather, 1970). The beach, which is relatively stable, consists mainly of fine to medium sand lying on a shingle subsurface layer or spit which is the original deposit. The sediments along the main transect are very well to moderately well sorted sand with variable amounts of shell fragments from the populations of the rocky margins and the subtidal (Fig. 2, Appendix Table I). Land drainage from the marshy backshore is responsible for the low salinities observed around MTL. Overall the beach is short (∿100 m), with a gradual increase in median diameter, carbon and chlorophyll content of the sediments from the upper to the lower foreshore.

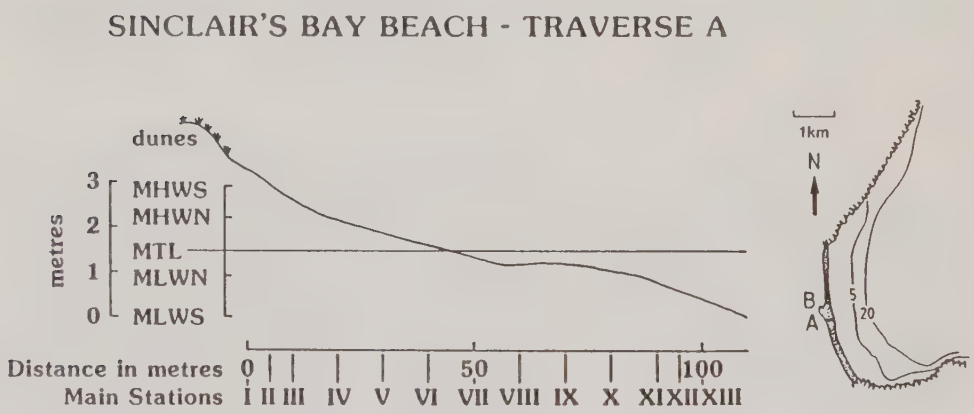


Figure 3. Sinclair's Bay beach profile, showing tidal levels and position of sampling stations. Map shows location of sampling traverses. Isobaths in metres.

Fauna

A total of nine species was present on this beach (Appendix Table II). The fauna was sparse with some levels devoid of animals. With the exception of a few specimens of *Paraonis fulgens* (Levinsen), oligochaetes and Nemertines, the fauna was dominated by the cirolanid isopod *Eurydice* and several species of the haustoriid amphipod *Bathyporeia.* The bulk of the amphipods, of which *Bathyporeia pelagica* (Bate) with a density of 192 per m^2 was the most abundant, were present below MTL. The extremes of the beach were inhabited by smaller concentrations of *Talitrus* and *Eurydice* at MHWN and *Haustorius* at MLWS.

The low overall abundance (maximum density 304 per m^2) and the total absence of bivalves and most polychaetes was responsible for the extremely low mean biomass of 0.03 gm^{-2} (range 0.00–0.125), to which the crustaceans contributed more than 87%.

2. Dornoch (Fig. 4)

Physical features

The beach lies to the north-east of the burgh beyond the Golf Club. Rocky outcrops and the extensive sandy spit of the Dornoch Firth fringe the beach and afford some protection from northerly winds and wave action to the otherwise exposed beach. The intertidal area is narrow (∿100 m) with a steep gradient and is fringed by a continuous dune system and a flattish backshore, delimited by a backing relict cliff. The sediments of the main transect are mainly well to moderately well sorted medium sand with small patches of finer grades at the lower foreshore (Fig. 2, Appendix Table I). There is some stratification of the grades at the lower forshore, which also contains small quantities of biogenic material. The beach is stable and constantly supplied with sand from the subtidal deposits (Smith and Mather, 1973). There is a gradient from the upper to the lower foreshore, with a decrease in the particle sizes at the MLWS level and an increase in the carbon and chlorophyll content of the sediments.

A generalised fresh water influence affects most levels, this being more pronounced around mid tide level.

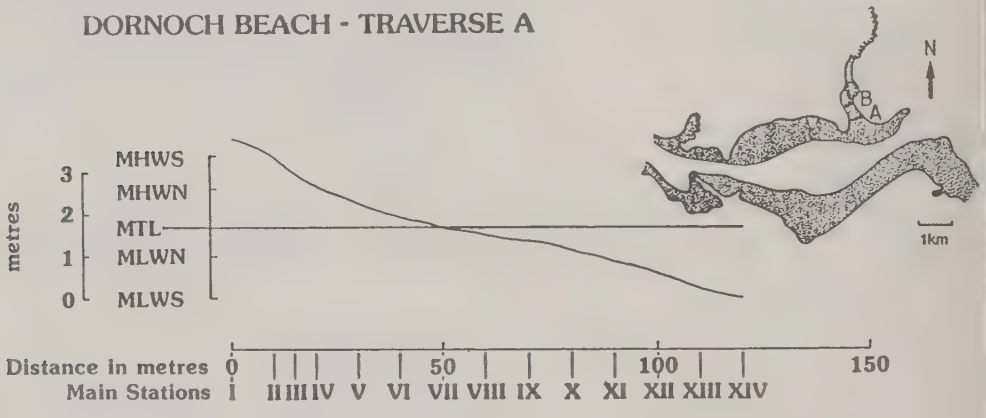


Figure 4. Dornoch beach profile and map. Details as in Figure 3.

Fauna

Of the 15 species collected on this beach (Appendix Table III), more than half consisted of peracarid crustaceans. Of these, more than 50% were haustoriid amphipods of the genus *Bathyporeia.* The isopod *Eurydice pulchra* (Sars) and the oedicerotid amphipod *Pontocrates arenarius* (Bate) were distributed over several levels, while cumaceans and talitrid amphipods were characteristically distributed at the lower and upper foreshore respectively. Small numbers of polychaetes such as *Nephtys cirrosa* Ehlers and *Scolelepis squamata* (O F Müller) and the tellinid *Tellina tenius* da Costa were confined to the lower limits of the beach.

The total abundance on the beach ranged from 0 to 1,792 individuals per m^2. Large densities of *Pontocrates arenarius,* up to 1,664 individuals per m^2, and *Eurydice pulchra,* with densities up to 208 individuals per m^2, chiefly contributed to this abundance. The low occurrence of polychaetes and bivalves was responsible for the very low biomass which ranged from 0 to 0.610 g m^{-2}, of which 77% was made up by the cirolanid isopods and talitrid amphipods.

3. Nairn (Fig. 5)

Physical features

This beach lies north-east of the burgh of Nairn and constitutes the western end of the extensive intertidal complex of the Culbin Sands. The intertidal area is rather large (280 m long) and its most important feature is a substantial sand ridge which creates multiple tidal levels and a large runnel below MTL. The inner location of this beach into the Firth and the presence of the ridge together provide it with effective protection. Bartrop *et al.* (1980) in their report classified this entire area as being moderately exposed

to wave action. There is a large berm which fringes the dune system at the backshore. West of this location the River Nairn enters the sea, and although the existing groynes limit its influence on the intertidal area, nevertheless lateral movements of fresh water could affect the neighbouring area at high water. The sediments of the main transect are fine sand (Fig. 2, Appendix Table I), mostly well sorted, showing some vertical stratification due mainly to the presence of important amounts of biogenic material. The beach is relatively stable although small scale ridge migration is probable. The sheltered conditions in the runnel promote fine sediments, where higher than average organic carbon and increased chlorophyll content accumulate. Sea water retained in the runnel is particularly affected by fresh water dilution, mostly due to the river influence.

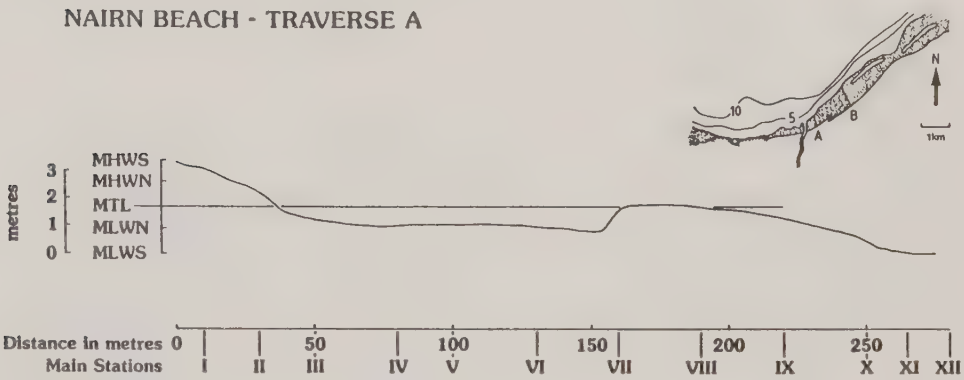


Figure 5. Nairn beach profile and map. Details as in Figure 3.

Fauna

The fauna along the main traverse included 30 species (Appendix Table IV) of which polychaetes accounted for 50% of the total. The composition of the fauna and its zonation were significantly influenced by the presence of the runnel in which polychaetes and bivalves found conditions resembling a sheltered beach, while crustaceans such as *Haustorius, Eurydice* and *Talitrus* occurred mainly on the more exposed ridge and slope. *Ophelia* and *Pygospio* were numerically dominant there with densities up to 1,040 and 576 per m^2 respectively. The presence of species such as *Spiophanes, Chaetozone, Bodotria* and *Spio* were associated with the very wet conditions prevailing in the runnel. Lowered salinities in the runnel favoured the presence of *Nereidae* and *Macoma balthica* while modest concentrations of *Capitella capitata* (Fabricius) (up to 336 per m^2) were favoured by the trapped organic matter in the runnel. High abundances and biomass were likewise found within the confines of the runnel. Densities ranged between 142 per m^2 in the wave-swept lower foreshore and a maximum of 2,736 individuals per m^2 in the runnel. The overall mean biomass of 1.176 g m^{-2} consisted mainly of *Cerastoderma, Macoma* and young tellinids, while what remained was equally apportioned between crustaceans and molluscs. The relatively high biomass (1.878 g m^{-2}) at MHWS was almost exclusively due to large concentrations of *Talitrus.*

Stephen (1929), in his work on the intertidal fauna of the beaches west and east of Nairn, found on the mixed deposits a combination of *Tellina* and *Cerastoderma-Macoma* associations occurring in larger densities at the lower foreshore than those found in the present survey. Elmhirst (1931), in his work on the intertidal crustaceans, found the same diversity but in smaller densities than in the present survey, probably as a result of the coarser sieve used to collect his samples.

4. Burghead (Fig. 6)

Physical features

Burghead Bay is a large shallow bay in the inner Moray Firth. It has a north-west-south-east axis and is partly protected from northerly winds and swell by Burghead promontory. Bartrop *et al.* (1980) classified it as a moderately exposed beach. The beach is stable and continuously supplied with sediment from the subtidal deposits and to a lesser extent from the eroding backshore dunes. Only two traverses in the middle part of the extensive sandy beach were sampled. A large stream enters the beach to the west of the sampling location and a number of smaller streams percolate through the backshore. There is a well-marked break at the MTL separating the steep upper part from a flattish, gently undulating lower foreshore, extensively rippled and retaining surface water.

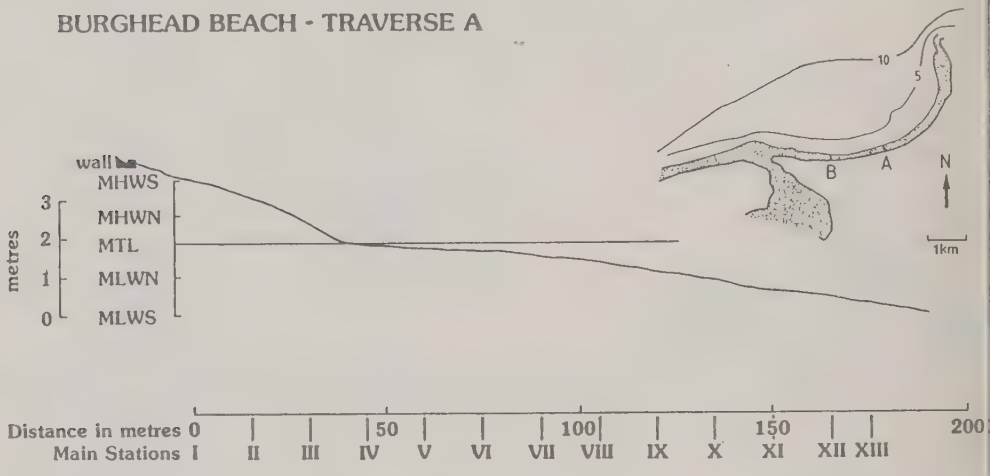


Figure 6. Burghead beach profile and map. Details as in Figure 3.

The sediments along the main transect are fine overall and well sorted (Fig. 2, Appendix Table I). There is little vertical stratification in the grades at the upper foreshore, but some subsurface patches of shell material and outcrops of peat are present in the flattish lower foreshore, mainly around MLWN. Evidence of fresh water influence is noticeable at the two extremes. Organic carbon and chlorophyll values are average for this type of beach but with higher values being present at the level of the slope break.

Fauna

A total of 24 species was present, with polychaetes and crustaceans being the dominant taxa (Appendix Table V). Of the polychaetes *Paraonis* was present throughout the beach and abundant, reacing a maximum density of 928 per m^2 below MTL. Other polychaetes such as *Scolelepis, Ophelia* and *Capitella* were present in modest densities, mostly found in the MHWN/MTL area. However the crustaceans, especially *Bathyporeia pilosa* Lindstrom, were by far the most numerous and were found almost throughout the beach. Densities in excess of 5,000 per m^2 were found at MLWN with smaller densities of *Bathyporeia sarsi* Watkin and *Haustorius* at several levels below MHWN; above this level localised concentrations of *Talitrus* occurred. The molluscs were represented by *Tellina* and *Donax,* of which the former was common and relatively abundant, showing a bimodal distribution. It is significant that the absence or decrease of many species from the MLWN level was associated with the marked decrease in salinity at that level. The presence of *Cerastoderma,* as reported by Bartrop *et al.* (1980), is not recorded in this survey. The abundance ranged from 176 per m^2 at the upper beach to a maximum of 5,488 per m^2 at MLWN. High biomass in certain stations (5.3 g m^{-2}) was due mostly to the presence of the bivalve *Tellina,* which made up 53% of the mean biomass (1.62 g m^{-2}).

5. Fraserburgh (Fig. 7)

Physical features

The examined beach lies in the western half of Fraserburgh Bay, a shallow bay exposed to the North Sea winds and swell from the north east sector. The beach is short (120 m), steep and with a smooth profile. The sediments consist of fine sand, with patches of medium sand being present at the lower half of both traverses (Fig. 2, Appendix Table I). Coarser deposits are found at the deeper layers of the lower foreshore. The beach is stable, and is supplied with sand from the shallow subtidal. The grades in the main traverse are well to moderately well sorted with an insignificant amount of shell debris. Enhanced levels of organic carbon and chlorophyll in the lower foreshore indicate the influence of organic inputs from the town and the port of Fraserburgh.

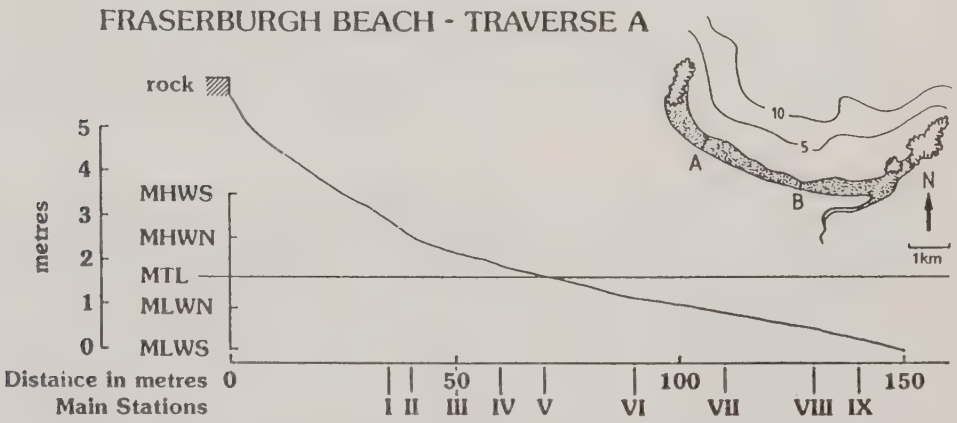


Figure 7. Fraserburgh beach profile and map. Details as in Figure 3.

Fauna

A total of 12 species was recorded on the main traverse (Appendix Table VI). With the exception of isolated occurrences of polychaetes and nemertini the fauna was dominated by crustaceans. Most of the fauna were present between MTL and MLWN, the extremes of the beach being very sparsely populated. The highest abundance of 544 per m^2 was recorded at MTL and below, where *Eurydice* and *Pontocrates arenarius* were present in densities up to 336 and 224 per m^2 respectively. The biomass was highest at the lower levels of the beach, where, despite the presence of a few larger polychaetes and the abundant crustaceans giving localised values of 1.12 g m^{-2}, the mean biomass was nevertheless only 0.24 g m^{-2}.

6. Rattray Head (Fig. 8)

Physical features

This is an extensive beach stretching for several miles north of Peterhead. The short beach (120 m) facing east is exposed to wind and wave action from many directions. The berm and the upper foreshore consist of dry loose sand, but the flattish lower foreshore is rippled with surface water extending to MLWN, where a large ridge extends to MLWS. The sediments show a gradient with fine, well sorted sand at the upper beach followed by medium, moderately well sorted sand at the lower beach (Fig. 2, Appendix Table I). Vertical stratification of the grades is insignificant although the sand contains appreciable quantities of fine mussel shell fragments. The beach is unstable and supplied continuously with sediment from the shallow subtidal. Fresh water influence from land drainage is evident at MTL, with salinities down to 15°/oo. Organic carbon and chlorophyll values are low but some localised higher values are found at the lower foreshore of both traverses.

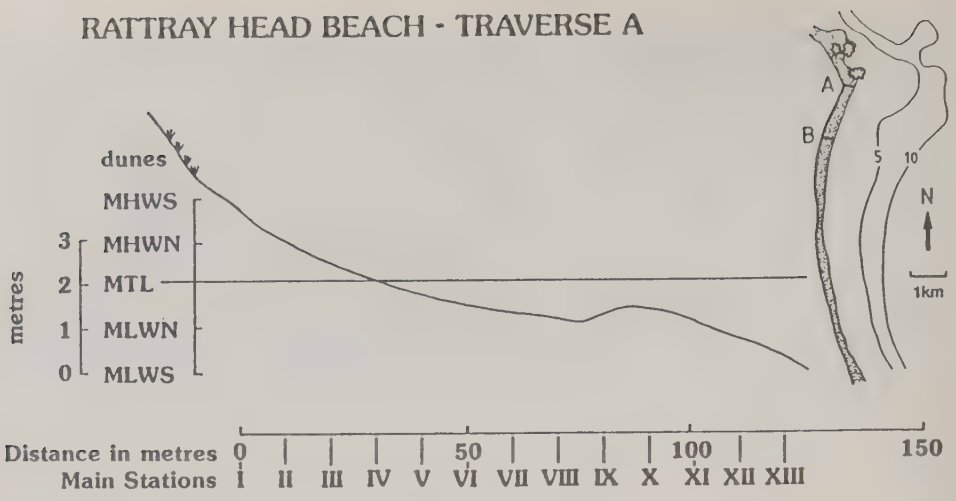


Figure 8. Rattray Head beach profile and map. Details as in Figure 3.

Fauna

With the exception of a single species of polychaete, oligochaetes and juvenile *Mytilus,* the fauna of 10 species consisted mainly of crustaceans (Appendix Table VII). *Haustorius* and *Eurydice* occurred at most levels and in appreciable densities, while significant aggregations of *Pontocrates arenarius* and *P. altamarinus* (Bate & Westwood) were found sporadically at certain stations. The bulk of the fauna occurred between MHWN and MLWN, with the station at MLWS devoid of fauna. Densities in excess of 1,000 per m^2 recorded in the middle of the beach were made up mainly by *Eurydice* and *Pontocrates arenarius.* Although the high densities of these species were responsible for biomass values up to 1.315 g m^{-2}, nevertheless the mean biomass, to which crustacea contributed 93%, was only 0.506 g m^{-2}.

7. Lunan Bay (Fig. 9)

Physical features

This is a large, sandy beach stretching for 4 km south of Montrose. The bay is shallow, and being slightly recessed between two headlands is sheltered to some extent from wave action but not from wave reflection. The beach is stable and continuously supplied with sediments from the shallow subtidal. The steep berm forms a continuation of the sand dunes of the backshore, from which two streams enter the beach, the larger of the two, the Lunan Water, occurring centrally. Several shallow runnels and ridges give an undulating outlook to the profile. The sand, dry at the upper foreshore, is wet and rippled at lower levels, with surface water present in the runnels. The sediments along the traverse are clean sand with a small quantity of shell fragments (Fig. 2, Appendix Table I). The grades are well sorted overall, with the coarser grades found on the upper half of the foreshore. The organic carbon and chlorophyll content of the sediments, low on the whole, correlate well with the particle size, the values being higher in the finer sediments of the lower foreshore.

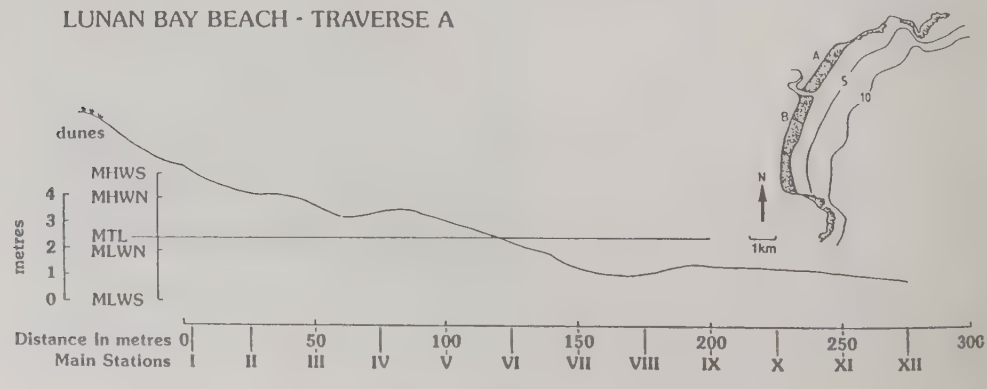


Figure 9. Lunan Bay beach profile and map. Details as in Figure 3.

Fauna

Twenty-six species were collected on the main traverse and the fauna of the secondary traverse was similar with only slight numerical differences (Appendix Table VIII). Crustaceans, which accounted for 15 species, were common and numerically dominated by haustoriid and oedicerotid amphipods. The dominant *Bathyporeia elegans* Watkin and *Haustorius* were widely distributed in densities of up to 464 and 400 per m^2 respectively. With the exception of *Scolelepis squamanta,* found in appreciable numbers (up to 448 per m^2) at most beach levels, the remaining polychaetes occurred sporadically and in low densities. Apart from a few juvenile bivalves molluscs were absent, although a small number of *Tellina tenuis* was found at the southern part of the Bay. The faunal abundance along the traverse reflected the crustacean densities. The corresponding biomass, although influenced by heavy specimens of *Scolelepis* at the upper foreshore, nevertheless had 80% of its mean value of 1.475 g m^{-2} made up by crustaceans.

8. Tentsmuir (Fig. 10)

Physical features

Tentsmuir is an extensive, sandy shore along the Fife coast, between the Firth of Tay and the River Eden. The beaches examined lie roughly in the middle of this shore, which is effectively protected from wave action by the larger sand spits and sand bars of the Abertay Sands. The beach is more than 200 m wide and the area above MTL occupies ¾ of the total length. In the middle of the beach there are runnels with standing water and ridges of fine sand, while the steep upper and lower foreshore consist of medium sand. The grades along the main traverse are moderately well sorted, with some vertical stratification in the deeper layers of the lower foreshore (Fig. 2, Appendix Table I). Coarser deposits are found in the secondary traverse.

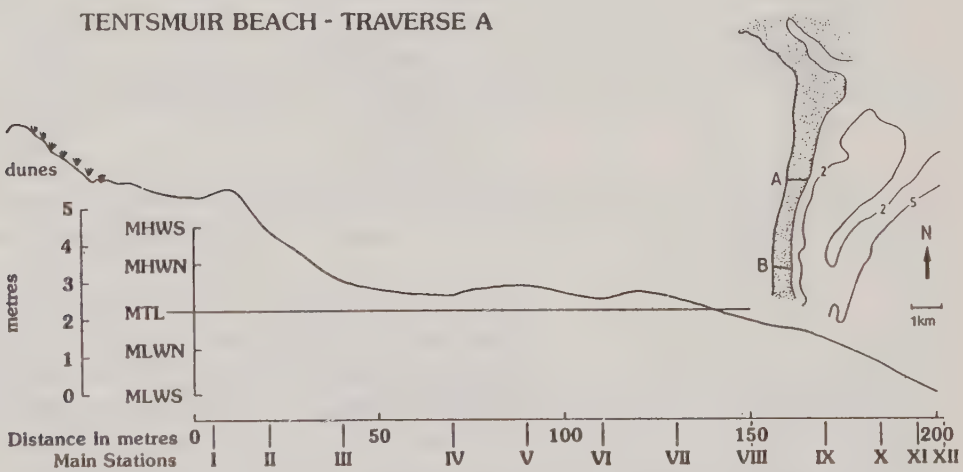


Figure 10. Tentsmuir beach profile and map. Details as in Figure 3.

The upper and lower extremes of the beach seem to be unstable, eroded by wind and tidal currents, but the beach as a whole is stable, supplied with sand from the deposits of the shallow subtidal. Organic carbon and chlorophyll values are markedly low, with values increasing in the lower foreshore.

Fauna

A total of 35 species was present on this beach (Appendix Table IX). There was an equal number of crustacean and polychaete species, with the exception of *Haustorius* and *Bathyporeia pilosa,* which were numerically important and occurred in high densities at the upper foreshore. The remainder was made up of the bivalves *Tellina tenius* and *T. fabula* Gmelin and Nemertini. The majority of the fauna was found around MTL and below. *Scolelepis, Spio, Paraonis* and *Nephtys cirrosa* were found in appreciable densities at these levels, while the sporadic presence of modest concentrations of *Cumopsis longipes* (Dohrn), *Eurydice* and *Paraonis* emphasised

the variability of the prevailing conditions. A sizeable *Tellina tenius* population was found below MTL in densities of up to 464 per m^2. The presence of appreciable densities of *Eulalia, Lanice, Bathyporeia elegans, B. guilliamsoniana* (Bate), *Microprotopus maculatus* Norman and *Tellina fabula* indicate a strong subtidal faunal influence. The numbers of the animals on the beach varied from 0 (MHWS) to 2,880 per m^2 (MLWS). There were considerable numerical fluctuations along the traverse, reflecting the variability of the prevailing conditions. The biomass followed closely the distribution of the polychaetes and bivalves (which accounted for 76% and 18.8% respectively of the mean biomass of 3.126 g m^{-2}.

9. St Andrews (Fig. 11)

Physical features

The examined beach forms part of the West Sands, a 3.5 km sandy stretch lying between the town of St Andrews and the mouth of the River Eden. The beach is long (450 m), with a low gradient and a gently undulating profile. Several shallow runnels, retaining variable amounts of water at low tide, are present throughout the intertidal area below MHWN.

The beach, backed by an extensive dune system, is stable and is supplied with sediments from the very shallow subtidal. Although the beach faces the open North Sea, the presence of the Abertay Sands in the north, the Fife Ness promontory in the south and the gently sloping subtidal in the east provide effective shelter from wind and wave action.

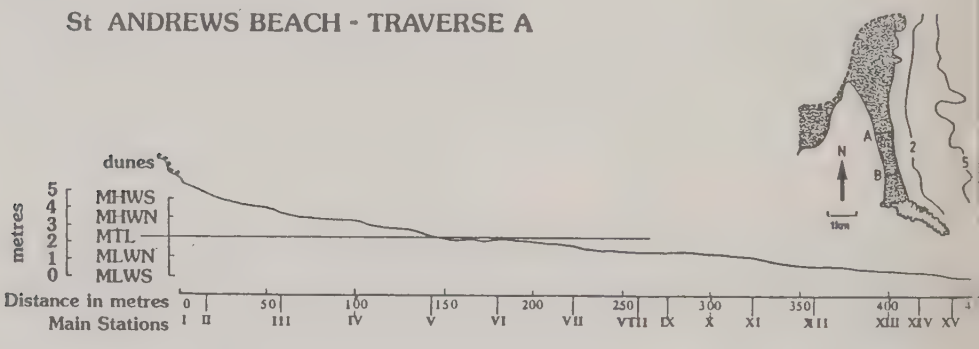


Figure 11. St Andrews beach profile and map. Details as in Figure 3.

The sediments along the main traverse consist mostly of very well sorted fine sand, with the finer deposits found at the lower foreshore (Fig. 2, Appendix Table I). There is evidence of fresh water dilution on the upper half of the beach, while organic carbon and chlorophyll values are average; however, enhanced values are recorded on a secondary traverse south of the main transect.

Although the sheltered nature of this location should promote high values of carbon and chlorophyll, the possible effects of the inputs from the eutrophied Eden estuary could be responsible for the erratic higher values recorded on other parts of this beach.

Fauna

The balanced physical conditions recorded were responsible for a varied fauna consisting of 35 species; of these, 28 were polychaetes and crustaceans occurring in equal numbers (Appendix Table X). Of the polychaetes *Nephtys cirrosa, Spiophanes bombyx* (Claparede) and *Spio filicornis* (O.F. Müller) were widely distributed at most tidal levels below MHWN. They were present in densities of up to 528, 352 and 144 individuals per m^2 respectively. Of the crustaceans, the haustoriid and oedicerotid amphipods showed a characterestic zonation, with *Bathyporeia pilosa* and *B. sarsi* found mainly above MTL. *Bathyporeia elegans, B. guilliamsoniana* and *Pontocrates altamarinus* were distributed on the lower foreshore, reaching their maximum abundance

around MLWS. The large densities of *Bathyporeia pilosa,* in excess of 1,900 individuals per m^2, were mainly due to the low salinities prevailing on the upper foreshore. The anomalous distribution and high abundance (6,416 individuals per m^2) of the normally subtidal cumacean *Bodotria pulchella* reflected the microenvironments created by the water retaining runnels at the mid and upper reaches of the beach. The presence of oligochaetes and insect larvae at MHWS also indicated the dilute nature of this environment.

The dominant molluscs were the tellinid bivalves *Tellina tenuis* and *Donax vittatus* (da Costa), their distribution at all levels below MHWN favoured by the prevailing sheltered conditions in the runnels, while densities of up to 800 and 1,056 individuals per m^2 respectively indicated large concentrations of suspended organic particles in the water column. Overall abundance per station ranged between 816 and 7,632 individuals per m^2, with densities being affected by the large concentrations of cumaceans, oligochaetes and amphipods.

At the upper foreshore, below MTL, an increasing gradient is evident in the faunal abundance. Biomass values, which ranged between 0.142 and 23.034 g m^{-2}, were dominated by the bivalve molluscs, which accounted for 88% of the mean biomass, reaching levels of 96% at certain stations.

Stephen (1929), in his study of the tidal zone of Scottish beaches, describes a fauna restricted to nine species from this area. These include the dominants *Tellina tenuis, Donax vittatus* and *Nephtys caeca* (Fabricius). This fauna shows a distribution similar to the one described in this paper. The polychaete *Nephtys caeca* (misidentified for *Nephtys cirrosa* according to Clark *et al.* (1962)) was reported in densities of up to 42 individuals per m^2. However, the stated maximum densities of *Tellina tenuis* (in excess of 1,000 individuals per m^2) and *Donax vittatus* (457 individuals per m^2) are correspondingly higher and lower than the densities found in the current survey.

The very restricted fauna reported by Stephen (1929) is at least partly due to the small number of stations taken as well as the large mesh size (2 mm) used in his sampling.

10. Gullane (Fig. 12)

Physical features

This is a small, sandy beach at the northern margin of the extensive Aberlady Bay. It is more than 300 m long with a low gradient and is very smooth at most levels, but has an undulating profile below MHWN with low ridges and runnels. The beach, which is fringed by an extensive dune system, is stable and constantly supplied with sediments from the gently shelving subtidal. Shelter from North Sea wave action is provided by the northwards projecting Lothian coast.

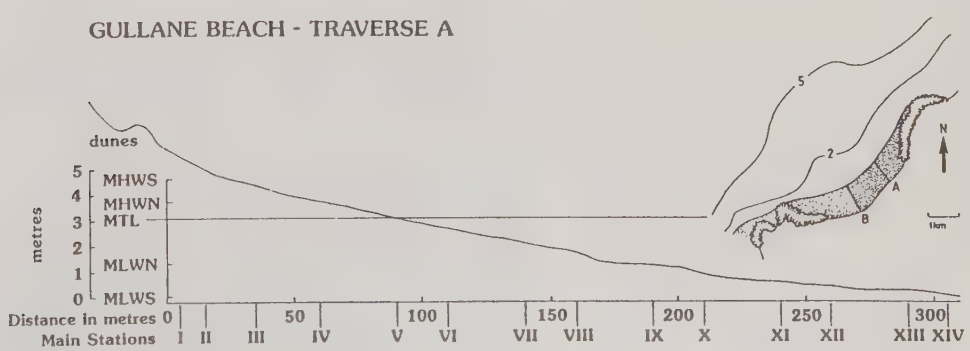


Figure 12. Gullane beach profile and map. Details as in Figure 3.

The sediments along the main traverse show a particle gradient from medium sand at the upper reaches to fine sand at the lower foreshore (Fig. 2, Appendix Table I). Variable amounts of biogenic material are responsible for the poorly sorted sediments at the upper reaches and the very well sorted sediments at MLWS. Several small fresh water streams enter the beach at high water causing some dilution which becomes evident throughout the extent of the main traverse.

The proximity of the beach to important inputs from Aberlady Bay and the Edinburgh area, in addition to its relatively sheltered location, may be responsible for the high organic carbon (894 μg g^{-1} sediment) and chlorophyll levels (in excess of 1.60 μg g^{-1} sediment).

Fauna

The fauna of this beach consisted of 46 species, of which 23 were crustaceans, 17 polychaetes and five bivalve molluscs (Appendix Table XI). The remainder include oligochaetes and dipteran larvae.

Haustoriid amphipods, such as *Bathyporeia elegans* and *B. guilliamsoniana* were common and abundant, reaching densities of up to 416 and 1,456 individuals per m^2 respectively. The oedicerotid *Pontocrates altamarinus* was widely distributed, reaching a maximum density of 864 individuals per m^2 in the lower reaches of the beach. The ridges and runnels of the lower foreshore constituted a suitable environment for many species of polychaete such as *Nephtys cirrosa, Spio filicornis* and *Paraonis fulgens* (the former being present in densities of up to 208 individuals per m^2). Even larger concentrations of *Scolelepis squamata* and *Ophelia rathkei* McIntosh were found at the MHWN to MTL zone of the beach.

Of the bivalves, *Tellina tenuis* was the only abundant species, showing an increasing population which reached a maximum of 496 individuals per m^2 between MLWN and MLWS.

The overall faunal density varied between 176 and 4,048 individuals per m^2 at the lower foreshore, where large concentrations of crustaceans were present.

The biomass values were greatly influenced by the proportion of *Tellina* individuals present at any one station. This varied from 0.02 g m^{-2} at the upper reaches of the beach where *Tellina* was not present, to a maximum of 24.586 g m^{-2} where *Tellina* contributed 88% of the overall biomass.

Stephen (1929), in his sampling of the LWM level of the beach, reports a fauna of nine species of which *Tellina tenuis* and *Nephtys caeca* were present in densities of 33 and 28 individuals per m^2. The low species diversity and abundance obtained by Stephen were probably due to the sampling technique used by the author. Furthermore, the discrepancy in the finding of *Nephtys caeca* in Gullane by Stephen (1929) was commented on by Clark *et al.* (1962), who also sampled Gullane beach and implied that Stephen might have misidentified *Nephtys cirrosa* as *N. caeca.*

11. Belhaven (Fig. 13)

Physical features

This beach, which lies west of the town of Dunbar, is an extension of the delta of the River Tyne, a small local river. The intertidal area is more than 200 m long and the profile is strongly sigmoid, with the extremes of the beach being short and very steep. The lower part is particularly steep and irregular. An important ridge and runnel system around MTL and a series of ridges between MTL and MLWS give a pronounced, irregular aspect to

this beach and indicate evidence of instability through exposure. The berm extends into a very large sedimentary delta and dune system in the back-shore. North and south-east of this location the River Tyne and a small stream enter the sea.

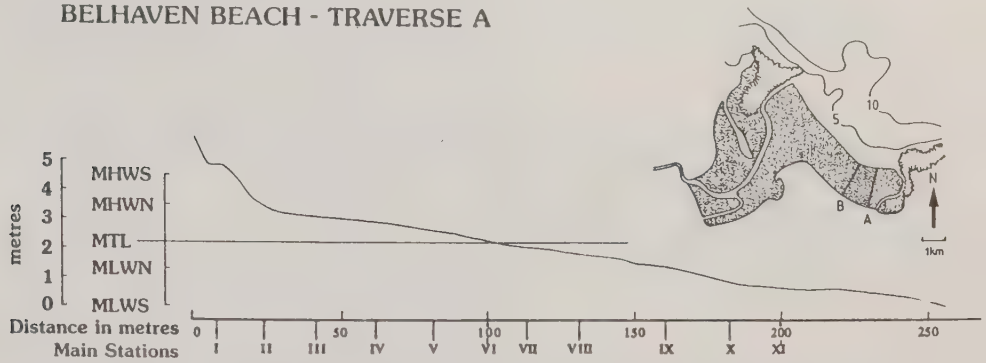


Figure 13. Belhaven beach profile and map. Details as in Figure 3.

The sediments of the main transect consist of poorly sorted medium sand showing no vertical or horizontal gradients (Fig. 2, Appendix Table I).

Organic carbon and chlorophyll values are particularly low, with the higher values being present at the lower foreshore.;

Fauna

Of the 18 species collected more than half were crustaceans (Appendix Table XII), mostly amphipods such as *Bathyporeia pelagica, Haustorius arenarius* (Slabber), *Pontocrates arenarius, P. altamarinus* and *Atylus swammerdami* (Milne-Edwards), and also the isopod *Eurydice pulchra.* Particularly abundant were *Atylus swammerdami* and *Bathyporeia pelagica* with concentrations of up to 2,880 and 1,408 individuals per m^2 respectively, Large concentrations of *Atylus* (2,880 individuals per m^2) were found at MLWS, while *Bathyporeia pelagica* and *Haustorius arenarius* were present in densities of 1,408 and 448 individuals per m^2 respectively.

Molluscs and polychaetes were virtually absent, and, with the exception of small numbers of *Scolelepis squamata,* the rest of the fauna was rather restricted. The overall faunal density showed an increasing gradient from 16 individuals per m^2 at station I to a maximum of 3,728 individuals per m^2 at station XI where the bulk consisted of amphipods.

The overall biomass was less than 1 g m^{-2} with a minimum of 0.001 g m^{-2} at station I to a maximum of 0.850 g m^{-2} at station VIII.

The individual station values followed very closely the distribution of the dominant crustaceans, which contributed more than 50% to the average biomass.

Discussion

The beaches of the eastern coast of Scotland are inhabited by a fauna (Appendix Table XIII) which is a variation of the north-temperate water community. This community is characterised by the bivalve *Tellina tenuis,* which is found fully developed in the sedimentary beaches of the west coast of Scotland (Eleftheriou and McIntyre, 1976).

The faunas on these east Scottish beaches fall into three main invertebrate groups: polychaetes, crustaceans and molluscs, and include the same species described and commented on by Stephen (1930) and Eleftheriou and

McIntyre (1976). Thus, on each beach, the upper foreshore is inhabited mainly by the crustaceans *Talitrus saltator* (Montagu) and *Bathyporeia pilosa*. The middle and lower reaches have a fauna of crustaceans such as *Eurydice pulchra, Haustorius arenarius, Bathyporeia pelagica* and *B. sarsi,* along with the polychaetes *Paraonis fulgens, Eteone longa* (Fabricius), *Ophelia rathkei* and *Scolelepis squamata.* The lower foreshores contain most of the fauna of polychaetes (*Spio filicornis, Nephtys cirrosa, Spiophanes bombyx* and *Lanice conchilega* [Pallas]), crustaceans (*Bathyporeia elegans, B. guilliamsoniana, Pontocrates altamarinus, P. arenarius, Atylus swammerdami* and *Pseudocuma gilsoni* Bacescu) and bivalves (*Tellina tenius* and *Donax vittatus*).

Where a beach has a gentle but undulating profile with an extensive water retaining ridge and runnel system, several species of polychaetes (*Spio filicornis, Paraonis fulgens, Levinsinia gracilis* [Tauber] and *Pygospio elegans*) and crustaceans (mainly the cumaceans *Bodotria pulchella, Cumopsis goodsiri, Cumopsis longipes* as well as the amphipods *Pontocrates arenarius* and *P. altamarinus*) extend their zonation by occupying these microhabitats at different tidal levels, well beyond their usual limits.

The variation in distribution and composition of the intertidal fauna in the different beaches is caused not only by topographical differences, but also by the result of the degree of exposure to which each beach is subject. Thus extreme conditions of exposure limit species richness by eliminating or severely restricting sedentary forms of polychaetes and bivalves, this fauna being dominated by fast swimmers such as the haustoriid (*Haustorius arenarius* and *Bathyporeia pelagica*) and oedicerotid amphipods (*Pontocrates spp*) and also cirolanid isopods (*Eurydice pulchra*). Increased shelter favours the presence of a species-rich and numerically abundant fauna characterised by the bivalve molluscs *Tellina tenuis* and *Donax vittatus,* the polychaetes *Nephtys cirrosa, Spio filicornis, Ophelia rathkei, Scolelepis squamata* and *Paraonis fulgens,* the amphipods *Bathyporeia elegans, B. guilliamsoniana, B. pilosa* and *B. sarsi* and also the cumaceans *Bodotria pulchella* and *Cumopsis goodsiri* which, under conditions of extreme shelter, are present in large numbers.

Examination of the faunal data employing indices such as the overall species richness, the relative importance of the different taxa and the mean abundance and biomass, along with the physical factors characteristic of each beach (such as the location and orientation of the main axis of the beach in relation to the prevailing winds and wave action [fetch], extent and gradient of the beach [slope] and the particle size and sorting coefficient of the sediment), reveals a range of values which reflect the prevailing degree of exposure and thus characterise each locality.

The effect of exposure on the faunal indices and physico-chemical characteristics has already been discussed by Eleftheriou and Nicholson (1975) and by Eleftheriou and McIntyre (1976). The former authors, by applying a multi-variate analysis to the physico-morphological characteristics and faunal indices from a number of north and west coast Scottish beaches, show that it is possible to discriminate between locations of different exposure. Thus, using the critical mean soil particle diameter of 232 μm (which separates exposed from sheltered beaches), it is possible to allocate the areas examined in this study to one of the two exposure categories.

Table XIV shows the physico-chemical characteristics and faunal indices of the examined beaches arranged into the two groups (exposed and sheltered) as defined above.

The first group, which includes the sheltered beaches (Nairn, Burghead, Tentsmuir, St Andrews and Gullane), is found at the inner part of firths, and is protected by headlands or by sandbanks. They are flat or gently undulating and consist of fine, sandy sediments ($\bar{x}$ = 201 μm). The fauna consists of 24–48 species of which a high percentage are sedentary forms present in high abundance and biomass.

The second group, representing the exposed beaches (Sinclair's Bay, Dornoch, Fraserburgh, Rattray, Lunan Bay and Belhaven) are located on the open coast. They are short, steep and consist of medium sand ($\bar{x}$ = 252 μm). The fauna is restricted to 9–26 species and includes very few sedentary forms. They are dominated by errant crustaceans whose overall abundance and biomass are low.

The relatively high biomass and abundance recorded at Lunan Bay are due to *Haustorius arenarius,* a species characteristic of exposed conditions.

The sheltered beaches have a mean range of particle size values from 158 to 233 μm, while the exposed areas have a corresponding range of 233–308 μm. This agrees well with the use of the critical mean diameter of 232 μm, as demonstrated previously by Eleftheriou and Nicholson (1975). Although the values for sediment organic carbon and chlorophyll content are not significantly different in the two groups, nevertheless conditions which allow for faster rates of supply, renewal and decomposition of organic matter on the sheltered beaches as against the exposed beaches should be taken into account. It should also be pointed out that the two groups of beaches include the same faunal elements, though in different numerical proportions (except for the crustaceans *Bathyporeia guilliamsoniana, Cumopsis goodsiri* and *Bodotria pulchella,* which are found only in sheltered conditions). There are similar elements recorded from other beaches of the Scottish coast (Eleftheriou and McIntyre, 1976) (except for *Bathyporeia sarsi,* which occurs in large concentrations in sheltered conditions).

A comparison of beaches from different parts of the coast points to differences and similarities in the physical and faunal characteristics. Thus, the faunal indices of the exposed east coast beaches are very similar to those exposed beaches from the north and west of Scotland (Eleftheriou and McIntyre, 1976); however, the faunal indices of the sheltered east coast beaches cover only the lower range of the values found on the sheltered west coast beaches. Furthermore, the subtidal faunal elements which invade the intertidal area of east coast beaches is rather insignificant; this is also true for species which are normally associated with algal growth.

The faunal details in conjunction with the physical characteristics reveal a coast where exposure is relatively severe, affecting, to a certain extent, even the upper parts of the more sheltered firths.

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APPENDIX – TABLES

Table I

Physico-chemical characteristics of beaches

Station No.	Distance (m) from fixed point	Tidal level	Sediment		Salinity S°/oo	Temp C	Carbon $\mu g\ g^{-1}$	Chlorophyll A $\mu g\ g^{-1}$
			Med diam MD (μm)	Sort coeff So				
Sinclair's Bay A		measured						
I	0	–	227.6	0.32	–	6.8	322	0.22
II	5	MHWS	–	–	–	7.0	–	–
III	10	–	–	–	34.0	–	–	–
IV	20	~MHWN	224.3	0.35	19.0	6.4	308	0.42
V	30	–	–	–	12.0	–	–	–
VI	40	–	–	–	19.0	–	–	–
–	45	MTL	–	–	–	–	–	–
VII	50	–	–	–	23.0	6.6	–	–
VIII	60	–	–	–	23.0	–	–	–
IX	70	–	–	–	33.0	–	–	–
X	80	–	–	–	35.0	–	–	–
–	85	MLWN	–	–	–	–	–	–
XI	90	–	–	–	–	–	–	–
XII	95	–	316.1	0.55	31.0	6.9	535	0.92
XIII	100	–	–	–	–	–	–	–
–	110	MLWS	–	–	–	–	–	–
Sinclair's Bay B		estimated						
I	0	HW	220.7	0.32	34.0	6.9	–	–
II	10	–	–	–	33.0	–	–	–
–	15	1/4	–	–	–	6.8	–	–
III	20	–	–	–	33.0	–	–	–
IV	30	MTL	231.4	0.34	33.0	7.5	–	–
V	40	–	–	–	27.0	–	–	–
–	45	3/4	–	–	–	5.8	–	–
VI	50	–	–	–	26.0	–	–	–
VII	60	–	–	–	30.0	–	–	–
VIII	70	–	–	–	28.0	–	–	–
IX	80	–	–	–	31.0	–	–	–
X	90	–	–	–	30.0	–	–	–
XI	100	–	–	–	33.0	–	–	–
XII	110	–	–	–	33.0	–	–	–
XIII	120	LW	237.6	0.37	34.0	5.5	–	–
XIV	135	–	–	–	–	–	–	–
Dornoch A		measured						
I	0	–	229.2	0.41	28.0	7.1	323	0.48
II	10	~MHWS	–	–	31.0	–	–	–
III	15	–	–	–	22.0	8.0	–	–
IV	20	~MHWN	–	–	29.0	–	–	–
V	30	–	–	–	26.0	–	–	–
VI	40	–	–	–	27.0	–	–	–
VII	50	MTL	273.7	0.51	29.0	8.5	405	0.89
VIII	60	–	–	–	30.0	–	–	–
IX	70	–	–	–	30.0	–	–	–
X	80	–	–	–	32.0	–	–	–
–	85	MLWN	–	–	–	–	–	–
XI	90	–	–	–	31.0	8.5	–	–
XII	100	–	–	–	30.0	–	–	–
XIII	110	–	–	–	33.0	–	–	–
XIV	120	MLWS	198.9	0.62	34.0	7.9	606	1.03
Dornoch B		estimated						
I	0	HW	248.2	0.42	29.0	7.9	–	–
II	10	–	–	–	–	–	–	–
III	20	–	–	–	33.0	–	–	–
IV	30	–	–	–	25.0	9.0	–	–
V	40	–	–	–	27.0	–	–	–
VI	50	–	–	–	31.0	–	–	–
VII	60	MTL	249.2	0.52	28.0	9.0	–	–
VIII	70	–	–	–	23.0	–	–	–
IX	80	–	–	–	30.0	8.8	–	–
X	90	–	–	–	32.0	–	–	–
XI	100	LW	237.1	0.54	30.0	7.1	–	–

Table I — Continued

Station No.	Distance (m) from fixed point	Tidal level	Sediment Med diam MD (μm)	Sediment Sort coeff So	Salinity S°/oo	Temp C	Carbon μg g^{-1}	Chlorophyll A μg g^{-1}
Nairn A		measured						
–	0	~MHWS	–	–	–	–	–	–
I	10	MHWN	218.3	0.99	33.5	17.4	306	0.06
–	25	MTL	–	–	–	–	–	–
II	30	–	–	–	35.0	18.0	–	–
III	50	–	200.3	0.43	32.5	15.0	415	1.26
IV	80	–	–	–	32.0	–	–	–
V	100	–	–	–	33.5	–	–	–
VI	130	–	–	–	30.0	–	–	–
–	140	MLWN	–	–	–	–	–	–
VII	160	–	–	–	–	–	–	–
VIII	190	–	–	–	35.0	–	–	–
IX	220	–	–	–	34.0	–	–	–
X	250	–	–	–	34.0	13.1	–	–
XI	265	–	–	–	–	–	–	–
–	270	~MLWS	–	–	–	–	–	–
XII	280	–	194.2	0.38	33.0	14.0	298	0.66
Nairn B		estimated						
I	0	HW	198.0	0.39	34.5	19.4	264	0.64
II	25	1/4	–	–	34.5	17.5	–	–
III	50	–	–	–	–	–	–	–
IV	75	MTL	200.8	0.39	32.0	15.5	349	1.59
V	95	–	–	–	–	–	–	–
VI	100	–	–	–	–	–	–	–
VII	125	–	–	–	–	–	–	–
VIII	150	–	–	–	–	–	–	–
IX	175	–	–	–	–	–	–	–
X	195	–	–	–	–	–	–	–
XI	205	3/4	–	–	30.0	13.3	–	–
XII	220	LW	194.3	0.64	30.5	15.5	280	0.83
Burghhead A		measured						
I	0	~MHWS	222.4	0.42	23.5	22.0	246	0.43
II	15	–	–	–	33.0	–	–	–
–	17	–	–	–	33.5	20.5	–	–
–	25	~MHWN	–	–	–	–	–	–
III	30	–	–	–	31.0	–	–	–
IV	45	~MTL	199.8	0.44	33.5	21.0	438	1.75
V	60	–	–	–	34.0	–	–	–
VI	75	–	–	–	33.5	–	–	–
VII	90	–	–	–	33.5	–	–	–
VIII	105	–	–	–	33.5	–	–	–
IX	120	–	–	–	33.5	–	–	–
–	130	MLWN	–	–	–	–	–	–
X	135	–	–	–	26.5	17.5	–	–
XI	150	–	–	–	31.5	–	–	–
XII	165	–	–	–	–	–	–	–
XIII	175	–	181.6	0.44	25.0	13.0	416	1.39
–	190	MLWS	–	–	–	–	–	–
Burghead B		estimated						
I	10	HW	246.3	0.46	34.0	21.2	279	0.35
II	25	1/4	–	–	33.5	19.2	–	–
III	40	–	–	–	32.5	–	–	–
IV	55	MTL	202.2	0.42	34.0	19.2	1,415	0.96
V	70	–	–	–	34.0	–	–	–
VI	85	–	–	–	34.5	–	–	–
VII	100	–	–	–	34.5	–	–	–
VIII	115	–	–	–	34.0	–	–	–
IX	130	3/4	–	–	34.5	16.5	–	–
X	145	–	–	–	32.0	–	–	–
XI	160	–	–	–	31.5	–	–	–
XII	175	LW	192.3	0.41	31.5	14.5	451	1.38

Table I — Continued

Station No.	Distance (m) from fixed point	Tidal level	Sediment Med diam MD (μm)	Sediment Sort coeff So	Salinity S°/oo	Temp C	Carbon $\mu g\ g^{-1}$	Chlorophyll A $\mu g\ g^{-1}$
Fraserburgh A		measured						
–	0	~MHWS	–	–	–	–	–	–
I	35	–	227.7	0.60	–	15.1	482	0.69
II	40	MHWN	–	–	–	–	–	–
–	45	–	–	–	35.0	15.5	–	–
III	50	–	–	–	–	–	–	–
IV	60	–	–	–	–	–	–	–
V	70	MTL	269.0	0.71	34.5	13.9	944	2.51
VI	90	–	–	–	–	–	–	–
VII	110	–	–	–	35.0	12.2	–	–
VIII	130	–	–	–	–	–	–	–
–	135	MLWN	239.2	0.68	–	12.8	914	3.17
IX	140	–	–	–	–	–	–	–
–	150	MLWS	–	–	–	–	–	–
Fraserburgh B		estimated						
I	20	HW	214.8	0.44	–	17.0	465	0.64
II	30	1/4	–	–	35.0	13.5	–	–
III	40	–	–	–	–	–	–	–
IV	50	MTL	229.1	–	34.5	13.8	737	2.21
V	70	–	–	–	–	–	–	–
VI	80	–	–	–	–	–	–	–
VII	100	–	–	–	–	–	–	–
VIII	110	3/4	–	–	35.0	–	–	–
IX	120	–	412.0	1.01	35.0	12.0	1,177	4.99
X	125	LW	–	–	–	–	–	–
Rattray Head A		measured						
I	0	~MHWS	239.8	0.34	–	11.2	190	0.07
II	10	MHWN	–	–	–	–	–	–
–	15	–	–	–	35.0	11.3	–	–
III	20	–	–	–	–	–	–	–
IV	30	MTL	284.8	0.60	15.5	11.2	529	1.01
V	40	–	–	–	–	–	–	–
VI	50	–	–	–	–	–	–	–
VII	60	–	–	–	–	–	–	–
VIII	70	–	–	–	32.0	10.9	–	–
IX	80	–	–	–	–	–	–	–
X	90	–	–	–	–	–	–	–
XI	100	~MLWN	–	–	–	–	–	–
XII	110	–	–	–	–	–	–	–
XIII	120	–	318.1	0.77	33.5	11.1	466	0.87
–	125	MLWS	–	–	–	–	–	–
Rattray Head B		estimated						
I	0	HW	229.8	0.34	–	12.0	212	0.07
II	10	–	–	–	–	–	–	–
III	20	1/4	–	–	34.5	11.0	–	–
IV	30	MTL	260.3	0.54	32.0	11.0	263	0.37
V	40	–	–	–	–	–	–	–
VI	50	–	–	–	–	–	–	–
VII	60	3/4	–	–	27.5	11.0	–	–
VIII	65	–	–	–	–	–	–	–
IX	70	–	–	–	–	–	–	–
X	80	–	–	–	–	–	–	–
XI	90	LW	328.8	0.82	33.0	11.0	654	1.74

Table I — Continued

Station No.	Distance (m) from fixed point	Tidal level	Sediment Med diam MD (μm)	Sediment Sort coeff So	Salinity S°/oo	Temp C	Carbon μg g^{-1}	Chlorophyll A μg g^{-1}
Lunan Bay A		measured						
I	3	MHWS	286.2	0.44	—	14.0	173	0.12
II	25	—	—	—	—	—	—	—
—	40	MHWN	—	—	—	—	—	—
III	50	—	—	—	—	—	—	—
IV	75	—	—	—	30.5	15.5	—	—
V	100	—	—	—	—	—	—	—
—	120	MTL	—	—	—	—	—	—
VI	125	—	—	—	—	—	—	—
—	140	MLWN	—	—	—	—	—	—
VII	150	—	261.8	0.55	31.5	14.5	281	0.34
VIII	175	—	—	—	—	—	—	—
IX	200	—	—	—	—	—	—	—
X	225	—	—	—	34.0	15.5	—	—
XI	250	—	—	—	—	—	—	—
XII	275	MLWS	216.0	0.39	35.0	15.2	320	0.33
Lunan Bay B		estimated						
I	5	HW	229.0	0.34	34.5	12.6	226	0.20
II	25	—	—	—	—	—	—	—
III	50	1/4	—	—	35.0	13.6	—	—
IV	75	—	—	—	—	—	—	—
V	100	—	—	—	—	—	—	—
—	110	MTL	253.0	0.43	34.5	13.8	272	0.22
VI	125	—	—	—	—	—	—	—
VII	150	—	—	—	—	—	—	—
VIII	175	—	—	—	—	—	—	—
IX	200	—	—	—	—	—	—	—
—	205	3/4	—	—	34.5	14.0	—	—
X	225	—	—	—	—	—	—	—
XI	250	LW	205.0	0.36	35.0	14.5	336	0.49
Tentsmuir A		measured						
I	5	—	—	—	—	—	—	—
—	12	~MHWS	235.7	0.57	33.5	11.2	311	0.05
II	20	—	—	—	—	—	—	—
—	25	—	207.0	0.54	34.0	13.5	—	—
—	30	MHWN	—	—	—	—	—	—
—	35	—	189.6	0.50	34.0	12.0	208	0.14
III	40	—	—	—	—	—	—	—
IV	70	—	—	—	—	—	—	—
V	90	—	—	—	—	—	—	—
VI	110	—	—	—	—	—	—	—
VII	130	—	—	—	—	—	—	—
—	140	MTL	—	—	—	—	—	—
VIII	150	—	—	—	—	—	—	—
IX	170	—	199.1	0.61	32.0	14.0	—	—
—	175	MLWN	—	—	—	—	—	—
X	185	—	—	—	—	—	—	—
XI	195	—	—	—	—	—	—	—
—	200	MLWS	233.8	0.66	30.5	13.5	335	0.59
XII	202	—	—	—	—	—	—	—
Tentsmuir B		estimated						
I	5	—	—	—	—	—	—	—
—	16	HW	344.5	—	33.5	8.5	221	0.04
II	20	—	—	—	—	—	—	—
—	25	—	—	—	33.5	14.0	—	—
—	30	1/4	386.5	—	34.0	11.2	—	—
III	60	—	—	—	—	—	—	—
IV	100	—	—	—	—	—	—	—
V	140	—	—	—	—	—	—	—
—	160	MTL	349.7	—	34.0	11.06	232	0.03
VI	180	—	—	—	—	—	—	—
VII	220	—	—	—	—	—	—	—
VIII	260	—	—	—	—	—	—	—
IX	280	—	—	—	—	—	—	—
X	300	LW	368.8	—	33.5	13.2	309	0.20

Table I — Continued

Station No.	Distance (m) from fixed point	Tidal level	Sediment Med diam Md (μm)	Sediment Sort coeff So	Salinity S°/oo	Temp C	Carbon $\mu g\ g^{-1}$	Chlorophyll A $\mu g\ g^{-1}$
St Andrews A		measured						
I	5	—	194.7	0.32	33.0	8.5	447	0.40
II	20	~MHWS	—	—	—	—	—	—
III	60	—	—	—	—	—	—	—
—	70	MHWN	—	—	—	—	—	—
IV	100	—	—	—	—	—	—	—
V	140	—	—	—	—	—	—	—
—	150	MTL	151.6	—	33.0	9.8	472	0.60
VI	180	—	—	—	—	—	—	—
VII	220	—	—	—	—	—	—	—
VIII	260	—	—	—	—	—	—	—
IX	280	—	—	—	—	—	—	—
X	300	—	—	—	—	—	—	—
XI	320	—	—	—	—	—	—	—
—	350	MLWN	149.3	0.32	35.0	11.0	—	—
XII	360	—	—	—	—	—	—	—
XIII	400	—	—	—	—	—	—	—
XIV	420	—	—	—	—	—	—	—
XV	440	—	—	—	—	—	—	—
—	450	—	139.4	0.44	35.5	11.0	638	0.45
XVI	460	MLWS	—	—	—	—	—	—
St Andrews B		estimated						
—	0	HW	165.2	—	22.0	8.8	701	0.44
I	5	—	—	—	—	—	—	—
II	20	—	—	—	—	—	—	—
—	40	1/4	185.5	—	31.0	9.4	—	—
III	60	—	—	—	—	—	—	—
IV	100	MTL	159.3	—	34.0	9.2	784	1.10
V	140	—	—	—	—	—	—	—
VI	180	—	—	—	—	—	—	—
VII	220	3/4	148.3	—	35.5	10.0	—	—
VIII	260	—	—	—	—	—	—	—
IX	300	—	—	—	—	—	—	—
X	340	—	—	—	—	—	—	—
XI	380	—	—	—	—	—	—	—
XII	400	—	—	—	—	—	—	—
XIII	410	—	—	—	—	—	—	—
—	420	LW	143.0	—	34.1	10.9	585	0.40
Gullane A		measured						
I	5	—	237.4	0.50	31.0	7.7	411	0.63
II	15	—	—	—	—	—	—	—
—	25	MHWS	—	—	—	—	—	—
III	35	—	360.8	1.06	20.5	14.1	—	—
IV	60	MHWN	—	—	—	—	—	—
V	90	MTL	211.8	0.70	28.5	11.7	549	1.65
VI	110	—	—	—	—	—	—	—
VII	140	—	—	—	—	—	—	—
VIII	160	—	—	—	—	—	—	—
—	180	MLWN	—	—	—	—	—	—
IX	190	—	—	—	—	—	—	—
X	210	—	—	—	—	—	—	—
XI	240	—	203.9	0.92	28.5	14.0	—	—
XII	260	—	—	—	—	—	—	—
XIII	290	—	—	—	—	—	—	—
XIV	305	—	156.6	0.31	28.5	13.5	894	1.00
—	310	MLWS	—	—	—	—	—	—
Gullane B		estimated						
I	5	HW	233.0	0.54	33.5	7.0	410	0.19
II	20	—	—	—	—	—	—	—
III	35	1/4	255.2	0.70	28.5	13.4	—	—
IV	60	—	—	—	—	—	—	—
V	90	MTL	221.3	0.89	33.5	11.2	590	1.22
VI	110	—	—	—	—	—	—	—
VII	140	—	—	—	—	—	—	—
VIII	160	—	—	—	—	—	—	—
IX	190	3/4	199.9	1.36	35.0	14.0	—	—
X	210	—	—	—	—	—	—	—
XI	240	—	—	—	—	—	—	—
XII	260	—	—	—	—	—	—	—
XIII	275	LW	152.5	0.29	34.0	12.8	786	1.10

Table I — Continued

Station No.	Distance (m) from fixed point	Tidal level	Sediment Med diam MD (μm)	Sediment Sort coeff So	Salinity S°/oo	Temp C	Carbon $\mu g\ g^{-1}$	Chlorophyll A $\mu g\ g^{-1}$
Belhaven A		measured						
I	5	–	250.1	0.43	–	14.8	194	0.26
–	15	MHWS	–	–	–	–	–	–
II	20	–	384.9	1.17	34.5	15.1	–	–
–	30	MHWN	–	–	–	–	–	–
III	40	–	260.7	0.70	34.5	14.3	406	0.19
–	55	MTL	–	–	–	–	–	–
IV	60	–	–	–	–	–	–	–
V	80	–	–	–	–	–	–	–
VI	100	–	–	–	–	–	–	–
VII	120	–	–	–	–	–	–	–
VIII	140	–	–	–	–	–	–	–
IX	160	–	382.6	1.06	34.0	13.8	–	–
–	170	MLWN	–	–	–	–	–	–
X	180	–	–	–	–	–	–	–
XI	200	–	267.5	1.03	32.5	14.1	510	0.29
–	205	MLWS	–	–	–	–	–	–
Belhaven B		measured						
I	10	MHWS	796.5	0.72	–	12.7	393	0.05
–	25	MHWN	–	–	–	–	–	–
II	30	–	419.6	0.64	34.5	12.9	334	0.20
III	40	–	–	–	–	–	–	–
IV	60	–	–	–	–	–	–	–
V	90	–	–	–	34.5	12.9	–	–
–	105	MTL	–	–	–	–	–	–
VI	110	–	–	–	–	–	–	–
VII	130	–	394.7	0.90	34.0	13.7	–	–
VIII	160	–	–	–	–	–	–	–
–	165	MLWN	–	–	–	–	–	–
IX	190	–	–	–	–	–	–	–
X	220	–	–	–	–	–	–	–
XI	250	–	–	–	–	–	–	–
XII	260	MLWS	289.9	0.68	34.5	12.5	275	0.38

Table II

East Coast Survey: Sinclair's Bay (A)

Station No.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII		
Traverse (distance in metres)	0	5	10	20	30	40	50	60	70	80	90	95	100		
Tidal level		MHWS		~MHWN		~MTL				~MLWN				~MLWS	
Numbers per m^2															
Nemertini	–	–	–	–	–	–	–	32	64	–	–	48	16		
Paraonis fulgens	–	–	–	–	–	–	–	–	–	–	–	–	16		
Oligochaeta	16	32	–	–	–	–	–	–	–	–	–	16	–		
Eurydice pulchra	16	–	–	129	96	96	–	–	16	64	48	–	–		
Talitrus saltator	48	48	–	–	–	–	–	–	–	–	–	–	–		
Bathyporeia elegans	–	–	–	–	–	–	–	64	–	–	–	–	–		
Bathyporeia pelagica	–	–	–	–	16	–	64	192	–	64	32	32	–		
Bathyporeia pilosa	–	–	–	–	–	–	–	16	–	16	–	–	–		
Haustorius arenarius	–	–	–	–	–	–	–	–	–	–	–	–	80		
TOTAL	80	80	0	128	112	16	64	304	80	144	96	112	112		
Traverse (distance in metres)	0	5	10	20	30	40	50	60	70	80	90	100	Mean	%	
Weight (grammes) per m^2															
Polychaeta	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.004	0.005	0.85
Crustacea	0.081	0.055	0.000	0.125	0.117	0.002	0.008	0.051	0.029	0.081	0.091	0.008	0.014	0.051	87.18
Others	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.025	0.028	0.000	0.000	0.016	0.014	0.007	11.97
GRAND TOTAL	0.083	0.057	0.000	0.125	0.117	0.002	0.008	0.076	0.057	0.083	0.091	0.024	0.032	0.0585	100.0

Table III

East Coast Survey: Dornoch (A)

Station No.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV
Traverse (distance in metres)	0	10	15	20	30	40	50	60	70	80	90	100	110	120
Tidal level	~MHWS		~MHWN				MTL			~MLWN				MLWS
Numbers per m^2														
Nemertini	–	–	–	–	128	112	–	–	–	–	–	–	–	–
Nephtys cirrosa	–	–	–	–	–	–	–	–	–	–	–	–	16	16
Scolelepis squamata	–	–	–	–	–	32	–	–	–	–	–	48	64	16
Paraonis fulgens	–	–	–	–	–	–	–	–	–	64	–	–	–	–
Oligochaeta	16	–	–	–	–	–	–	–	–	–	–	–	–	–
Cumopsis goodsiri	–	–	–	–	–	–	–	–	–	–	32	32	48	48
Eurydice pulchra	–	–	48	208	64	32	80	80	96	16	96	48	–	–
Talitrus saltator	240	–	16	–	–	–	–	–	–	–	–	–	–	–
Bathyporeia elegans	–	–	–	–	–	–	–	–	–	–	16	–	–	–
Bathyporeia pelagica	–	–	–	16	32	–	16	32	32	16	32	–	–	16
Bathyporeia pilosa	–	–	–	–	16	–	–	–	16	–	–	–	–	–
Pontocrates arenarius	–	–	–	32	16	32	32	48	96	144	416	400	1,072	1,664
Gastrosaccus spinifer	–	–	–	–	–	–	16	48	64	16	16	16	–	–
Mytilus edulis	–	–	–	–	–	–	–	16	–	–	–	–	–	16
Tellina tenuis	–	–	–	–	–	–	–	–	–	16	–	–	80	16
TOTAL	256	0	64	256	256	208	144	224	304	256	624	544	1,280	1,792

Table III — Continued

Traverse (distance in metres)	0	10	15	20	30	40	50	60	70	80	90	100	110	120	Mean	%
Weight (grammes) per m^2																
Polychaeta	0.000	0.000	0.000	0.000	0.000	0.009	0.000	0.000	0.000	0.033	0.000	0.069	0.033	0.008	0.011	5.39
Crustacea	0.609	0.000	0.095	0.228	0.065	0.034	0.055	0.166	0.366	0.058	0.213	0.128	0.085	0.097	0.157	76.96
Mollusca	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.017	0.000	0.268	0.077	0.026	12.75
Others	0.001	0.000	0.000	0.000	0.049	0.095	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.10	4.90
TOTAL	0.610	0.000	0.095	0.228	0.114	0.138	0.055	0.167	0.366	0.091	0.230	0.197	0.386	0.182	0.204	100
Large Organisms																
Nephtys cirrosa													0.108	0.160	0.019	
GRAND TOTAL	0.610	0.000	0.095	0.228	0.114	0.138	0.055	0.167	0.366	0.091	0.230	0.197	0.494	0.342	0.223	

Table IV

East Coast Survey : Nairn (A)

Station No.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Traverse (distance in metres)	10	30	50	80	100	130	160	190	220	250	265	280
Tidal level	~MHWS	~MHWN	~MTL			~MLWN						~MLWS
Numbers per m^2												
Nemertini	–	–	80	240	176	64	336	16	128	–	16	96
Eulalia viridis	–	–	–	–	16	–	–	–	–	–	–	–
Eteone longa	–	16	176	80	64	96	112	–	–	–	–	–
Streptosyllis websteri	–	–	–	–	16	–	–	–	–	–	–	–
Syllidae	16	–	–	–	–	–	–	–	–	–	–	–
Nereis sp. (Juvs)	–	–	576	32	16	64	16	–	–	–	16	–
Nephyts cirrosa	–	–	–	–	–	32	48	–	–	–	–	16
Scolelepis squamata	–	128	32	–	–	–	–	–	48	32	–	32
Spiophanes bombyx	–	–	–	16	16	–	–	–	–	–	–	–
Spio filicornis	–	–	64	–	–	16	–	–	–	–	–	–
Pygospio elegans	–	–	–	224	208	576	208	–	–	–	–	–
Spio. sp. (Jurs)	–	–	–	32	–	–	–	–	–	–	–	–
Paraonis fulgens	–	–	256	192	160	160	16	–	16	–	32	96
Chaetozone setosa	–	–	–	16	–	–	–	–	–	–	–	–
Ophelia rathkei	–	–	1,040	16	48	–	64	256	16	64	16	–
Capitella capitata	–	–	192	272	16	64	336	–	–	–	–	–
Oligochaeta	48	–	–	–	–	–	–	–	–	–	–	–
Bodotria pulchella	–	–	–	–	–	–	–	–	–	–	48	–
Eurydice pulchra	16	304	–	–	–	–	–	224	336	–	–	–
Talitrus saltator	224	16	–	–	–	–	–	–	–	–	–	–

Table IV — Continued

Bathyporeia elegans	—	—	—	—	—	—	—	—	—	—	—	16		
Bathyporeia pilosa	—	—	—	—	48	—	—	16	96	—	96	48		
Bathyporeia sarsi	—	—	112	16	112	32	128	—	112	—	32	48		
Haustorius arenarius	—	—	—	—	—	—	32	16	80	—	16	16		
Pontocrates arenarius	—	—	—	—	—	—	—	—	—	16	—	—		
Rissoa sp.	32	16	96	16	—	—	—	—	—	—	—	—		
Cerastoderma edule	—	—	16	16	—	32	16	—	—	—	—	—		
Macoma balthica	—	—	96	16	16	64	—	—	—	—	16	—		
Tellina tenuis	—	—	—	—	—	—	16	—	—	—	—	—		
Tellinidae	—	—	—	—	64	—	—	—	—	—	—	—		
TOTAL	336	480	2,736	1,184	976	1,200	1,328	528	832	142	288	368		
Traverse (distance in metres)	10	30	50	80	100	130	160	190	220	250	265	280	Mean	%
Weight (grammes) per m^2														
Polychaeta	0.002	0.485	0.717	0.166	0.075	0.427	1.387	0.102	0.118	0.028	0.011	0.093	0.301	43.560
Crustacea	1.864	0.315	0.113	0.017	0.101	0.023	0.244	0.229	0.332	0.003	0.182	0.091	0.293	42.402
Mollusca	0.012	0.007	0.053	0.010	0.001	0.681	0.174	0.000	0.000	0.000	0.031	0.000	0.081	11.722
Others	0.000	0.000	0.023	0.037	0.008	0.005	0.018	0.012	0.032	0.000	0.000	0.056	0.016	2.315
TOTAL	1.878	0.807	0.906	0.230	0.185	1.136	1.823	0.343	0.482	0.031	0.227	0.240	0.691	99.99
Large Organisms														
Cerastoderma edule			0.413	1.164		3.256							0.403	
Macoma balthica					0.626								0.052	
Tellina tenuis							0.365						0.030	
GRAND TOTAL	1.878	0.807	1.319	1.394	0.811	4.392	2.198	0.343	0.482	0.031	0.227	0.240	1.176	

Table V

East Coast Survey : Burghshead (A)

Station No.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	
Traverse (distance in metres)	0	15	30	45	60	75	90	105	120	135	150	165	175	
Tidal level	~MHWS		~MHWN	~MTL						~MLWN				~MLWS
Numbers per m^2														
Anthozoa	–	–	–	–	–	–	–	–	–	–	–	–	16	
Nemertini	–	–	32	–	80	96	64	–	16	64	80	32	144	
Eteone longa	–	–	16	32	16	–	–	–	–	–	–	–	–	
Nephtys cirrosa	–	–	–	16	–	–	16	–	–	–	–	–	–	
Scolelepis squamata	–	16	224	48	32	–	–	–	32	–	64	–	32	
Spiophanes bombyx	–	–	–	–	–	–	–	–	–	–	16	32	48	
Pygospio elegans	–	–	–	32	32	–	–	–	–	–	–	–	–	
Paraonis fulgens	–	16	1,536	656	928	368	496	240	272	32	560	592	512	
Ophelia rathkei	–	–	–	–	64	16	–	–	–	–	16	16	–	
Capitella capitata	–	–	80	32	16	16	16	–	–	–	32	16	–	
Arenicola marina	–	–	–	–	–	–	16	–	–	–	–	–	–	
Scoloplos armiger	–	–	–	–	–	–	–	–	–	–	–	–	16	
Oligochaeta	160	48	–	–	–	16	–	–	–	–	–	–	–	
Cumopsis goodsiri	–	–	–	–	–	–	32	16	48	–	16	144	–	
Eurydice pulchra	16	80	–	16	–	–	16	–	16	–	–	–	32	
Talitrus saltator	256	–	–	–	–	–	–	–	--	–	–	–	–	
Bathyporeia elegans	–	–	–	–	16	–	–	–	–	–	–	16	96	
Bathyporeia pelagica	–	–	–	–	–	–	–	16	–	80	32	64	–	
Bathyporeia pilosa	–	16	272	176	112	176	272	16	128	5,008	176	80	48	
Bathyporeia sarsi	–	–	64	80	144	16	–	32	32	224	–	–	–	

Table V — Continued

Haustorius arenarius	—	—	48	48	48	32	48	16	16	48	32	16	—		
Pontocrates arenarius	—	—	—	16	—	—	32	16	—	—	—	80	32		
Tellina tenuis	—	—	—	—	16	16	32	80	288	32	80	96	208		
Donax vittatus	—	—	—	—	—	—	—	—	—	—	—	16	16		
TOTAL	432	176	2,272	1,152	1,504	752	1,040	432	848	5,488	1,104	1,200	1,200		
Traverse (distance in metres)	0	15	30	45	60	75	90	105	120	135	150	165	175	Mean	%
Weight (grammes) per m^2															
Polychaeta	0.000	0.013	1.166	0.474	0.063	0.115	0.115	0.018	0.032	0.004	0.586	0.070	0.071	0.241	16.78
Crustacea	2.948	0.062	0.102	0.136	0.186	0.085	0.186	0.041	0.069	0.818	0.031	0.053	0.125	0.372	25.91
Mollusca	0.000	0.000	0.000	0.000	0.000	0.000	0.442	1.026	5.199	0.812	0.727	1.030	1.156	0.799	55.64
Others	0.016	0.005	0.022	0.000	0.025	0.033	0.037	0.000	0.018	0.003	0.092	0.012	0.046	0.024	1.67
TOTAL	2.964	0.170	1.290	0.610	0.642	0.181	0.780	1.085	5.318	1.637	1.436	1.165	1.398	1.436	100.00
Large Organisms															
Nephtys cirrosa				0.926			0.703							0.125	
Tellina tenuis					0.384	0.442								0.064	
GRAND TOTAL	2.964	0.170	1.290	1.536	1.026	0.623	1.483	1.085	5.318	1.637	1.436	1.165	1.398	1.625	

Table VI

East Coast Survey : Fraserburgh (A)

Station No.	I	II	III	IV	V	VI	VII	VIII	IX
Traverse (distance in metres)	35	40	50	60	70	90	110	130	140
Tidal level	~MHWS	MHWN			MTL			~MLWN	~MLWS
Numbers per m^2									
Nemertini	–	–	–	–	48	–	–	–	–
Scolelepis squamata	–	–	–	–	64	–	–	–	–
Malacoceros fuliginosa	–	–	–	–	–	–	–	16	–
Paraonis fulgens	–	–	–	–	–	–	16	16	–
Oligochaeta	+	16	–	–	–	–	–	80	–
Eurydice pulchra	–	–	224	48	96	336	32	32	32
Bathyporeia pelagica	–	–	–	–	–	64	16	16	32
Stenothoe monoculoides	–	–	–	–	–	–	–	16	–
Pontocrates altamarinus	–	–	16	–	–	–	–	–	–
Pontocrates arenarius	–	–	–	80	21	144	224	48	–
Schistomysis spiritus	–	–	16	–	–	–	–	–	–
Rissoa sp.	–	16	16	–	–	–	32	–	–
TOTAL	0	32	272	128	240	544	320	224	64

Table VI — Continued

Traverse (distance in metres)	35	40	50	60	70	90	110	130	140	Mean	%
Weight (grammes) per m^2											
Polychaeta	0.000	0.000	0.000	0.000	1.082	0.000	0.009	0.010	0.000	0.122	50.622
Crustacea	0.000	0.000	0.362	0.104	0.046	0.455	0.052	0.014	0.004	0.115	47.718
Mollusca	0.000	0.003	0.010	0.000	0.000	0.000	0.014	0.000	0.000	0.003	1.245
Others	0.000	0.002	0.000	0.000	0.001	0.000	0.000	0.002	0.000	0.0006	0.249
TOTAL	0.000	0.005	0.372	0.104	1.129	0.455	0.075	0.026	0.004	0.241	99.8

Table VII

East Coast Survey : Rattray Head (A)

Station No.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	
Traverse (distance in metres)	0	10	20	30	40	50	60	70	80	90	100	110	120	
Tidal level	~MHWS	MHWN		MTL						~MLWN				MLWS
Numbers per m^2														
Scolelepis squamata	–	–	–	16	–	–	–	–	–	–	–	–	–	
Oligochaeta	128	592	80	–	–	–	–	–	–	–	–	64	–	
Eurydice pulchra	–	–	608	32	912	352	304	80	320	112	80	32	–	
Talitrus saltator	48	–	–	–	–	–	–	–	16	–	–	–	–	
Bathyporeia pelagica	–	–	–	–	32	–	–	16	16	–	16	–	–	
Bathyporeia pilosa	–	–	–	–	–	16	–	32	–	–	–	–	–	
Haustorius arenarius	–	–	48	112	96	16	48	–	112	–	–	32	–	
Pontocrates altamarinus	–	–	–	–	–	560	–	304	–	–	–	–	–	
Pontocrates arenarius	16	–	–	–	48	–	672	–	–	–	–	32	–	
Mytilus edulis	–	–	–	–	–	48	–	–	–	–	–	–	–	
TOTAL	192	592	736	160	1,088	992	1,024	432	464	112	96	160	0	

Table VII — Continued

Traverse (distance in metres)	0	10	20	30	40	50	60	70	80	90	100	110	120	Mean	%
Weight (grammes) per m^2															
Polychaeta	0.000	0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0006	0.158
Crustacea	0.720	0.000	1.017	0.562	1.315	0.401	0.534	0.089	0.868	0.116	0.081	0.420	0.000	0.471	93.083
Mollusca	0.000	0.000	0.000	0.000	0.000	0.382	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.029	5.731
Others	0.013	0.041	0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.0052	1.028
TOTAL	0.733	0.041	1.029	0.572	1.315	0.783	0.534	0.089	0.868	0.116	0.081	0.422	0.000	0.506	100.000

Table VIII

East Coast Survey : Lunan Bay (A)

Station No.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Traverse (distance in metres)	3	25	50	75	100	125	150	175	200	225	250	275
Tidal level	MHWS	~MHWN			~MTL	~MLWN						MLWS
Numbers per m^2												
Nemertini	–	16	16	16	32	16	–	–	–	–	16	16
Eteone longa	–	–	–	16	–	–	–	–	–	–	–	–
Phyllodocidae	–	–	–	–	16	–	–	–	–	–	–	–
Nephyts cirrosa	–	–	–	–	–	–	16	–	48	16	32	32
Scolelepis squamata	–	448	32	36	48	16	64	–	–	16	96	96
Spio filicornis	–	–	–	–	–	–	–	–	–	–	16	16
Paraonis fulgens	–	16	–	–	–	–	–	–	16	–	80	80
Ophelia rathkei	–	16	–	–	80	–	–	–	–	–	–	–
Oligochaeta	–	16	96	–	–	–	–	–	–	–	–	–
Pseudocuma gilsoni	–	–	–	–	–	–	16	–	–	–	–	32
Eurydice pulchra	–	–	–	–	96	–	–	–	–	–	–	–
Idotea baltica	–	–	–	–	–	–	–	–	48	–	–	–
Idotea sp.	–	–	–	–	–	16	–	–	–	–	–	–
Talitrus saltator	448	–	–	–	–	–	–	–	–	–	–	–
Gammarus locusta	–	–	–	–	–	–	16	–	–	16	16	–
Bathyporeia elegans	–	32	32	64	16	–	–	–	272	464	208	208
Bathyporeia guilliamsoniana	–	–	–	16	–	–	–	–	32	–	16	16

Table VIII — Continued

Bathyporeia pelagica	—	—	—	32	—	32	16	—	32	64	128	128		
Bathyporeia pilosa	—	—	—	—	—	—	—	—	—	—	—	32		
Haustorius arenarius	—	112	32	96	64	16	400	—	64	288	—	144		
Perioculodes longimanus	—	—	—	—	—	—	16	—	—	—	—	—		
Pontocrates altamarinus	—	—	—	—	—	—	—	—	48	80	80	32		
Pontocrates arenarius	—	—	—	32	—	96	80	—	—	32	32	—		
Atylus swammerdami	—	—	—	—	—	32	—	—	—	112	112	—		
Mytilus edulis	—	—	—	16	16	—	—	—	—	—	—	—		
Cyprina islandica	—	—	—	—	—	—	16	—	—	—	—	—		
TOTAL	448	656	208	324	368	224	640	0	560	1,098	832	832		
Traverse (distance in metres)	3	25	50	75	100	125	150	175	200	225	250	275	Mean	%
Weight (grammes) per m^2														
Polychaeta	0.000	1.126	0.124	0.374	0.848	0.310	0.050	0.000	0.045	0.023	0.092	0.096	0.257	18.7
Crustacea	6.165	0.071	0.486	0.075	0.091	0.038	3.850	0.000	0.181	1.094	0.278	0.947	1.106	80.6
Mollusca	0.000	0.000	0.000	0.002	0.004	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.001	0.1
Others	0.000	0.017	0.014	0.032	0.007	0.000	0.000	0.000	0.000	0.000	0.015	0.015	0.008	0.6
TOTAL	6.165	1.214	0.624	0.483	0.950	0.690	3.902	0.000	0.226	1.117	0.385	1.058	1.372	100.0
Large Organisms														
Nephyts cirrosa							0.893						0.074	
GRAND TOTAL	6.165	1.214	0.624	0.483	0.950	0.690	4.795	0.000	0.226	1.117	0.385	1.058	1.475	

Table IX

East Coast Survey : Tentsmuir (A)

Station No.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Traverse (distance in metres)	5	20	40	70	90	110	130	150	170	185	195	202
Tidal level	~MHWS	~MHWN					~MLT		~MLWN			~MLWS
Numbers per m^2												
Nemertini	–	–	–	–	48	32	16	–	–	16	–	32
Aphroditidae	–	–	–	–	–	–	–	–	–	–	–	32
Eulalia viridis	–	–	–	–	–	–	–	–	–	–	–	368
Autolytus sp.	–	–	–	–	–	–	–	–	–	–	–	16
Syllidae	–	–	–	–	–	–	–	–	–	–	–	16
Nephtys caeca	–	–	–	–	–	–	–	–	–	–	–	48
Nephtys cirrosa	–	–	–	–	–	–	–	16	48	160	–	64
Scolelepis squamata	–	–	–	–	96	16	144	80	16	32	–	–
Spiophanes bombyx	–	–	–	–	–	–	–	–	–	–	–	16
Malacoceros fuliginosa	–	–	–	–	–	–	–	16	–	–	–	–
Spio filicornis	–	–	–	–	–	–	–	16	48	272	–	176
Spio. sp. (Juvs)	–	–	–	–	–	40	–	320	–	–	–	–
Paraonis fulgens	–	–	–	–	–	–	–	16	128	208	–	–
Paraonis sp.	–	–	–	–	16	–	–	–	–	–	–	–
Cirratulidae	–	–	–	–	16	–	–	–	–	–	–	–
Capitellidae	–	–	–	–	–	–	–	32	–	–	–	32
Lanice concheliga	–	–	–	–	–	–	–	–	–	–	–	464
Cumopsis goodsiri	–	–	–	–	–	–	–	–	192	160	–	32
Cumopsis longipes	–	–	–	–	–	–	–	176	–	–	–	–
Pseudocuma gilsoni	–	–	–	–	–	16	–	32	–	–	–	32

Table IX — Continued

Eurydice pulchra	—	—	16	—	—	—	176	—	48	—	—	—		
Idotea pelagica	—	—	—	—	—	—	—	16	—	—	—	—		
Talitrus saltator	—	—	16	—	—	—	—	—	—	—	—	—		
Gammarus locusta	—	—	—	—	—	—	—	—	48	16	—	176		
Bathyporeia elegans	—	—	—	—	—	—	—	—	32	192	—	256		
Bathyporeia guilliamsoniana	—	—	—	—	—	—	—	64	—	48	—	224		
Bathyporeia pilosa	—	32	144	—	—	48	32	64	—	—	—	—		
Haustorius arenarius	—	—	176	16	32	160	—	48	64	—	—	—		
Pontocrates altamarinus	—	—	—	—	—	—	—	128	—	32	—	240		
Pontocrates arenarius	—	—	—	—	—	—	—	16	16	—	—	—		
Atylus swammerdami	—	—	—	—	—	16	—	—	16	—	—	64		
Miroprotopus maculatus	—	—	—	—	—	—	—	—	—	—	—	80		
Mytilus edulis	—	—	—	—	—	16	16	272	—	—	—	176		
Tellina tenuis	—	—	—	—	—	—	—	32	64	464	464	304		
Tellina fabula	—	—	—	—	—	—	—	—	—	—	—	32		
TOTAL	0	32	352	16	208	344	384	1,344	720	1,600	464	2,880		
Traverse (distance in metres)	5	20	40	70	90	110	130	150	170	185	195	202	Mean	%
Weight (grammes) per m^2														
Polychaeta	0.000	0.000	0.000	0.000	0.551	0.001	0.406	0.076	0.300	0.914	0.000	26.349	2.383	76.232
Crustacea	0.000	0.017	0.173	0.001	0.005	0.015	0.124	0.427	0.555	0.055	0.000	0.430	0.150	4.798
Mollusca	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.512	0.949	0.949	0.000	4.669	0.590	18.874
Others	0.000	0.000	0.000	0.000	0.023	0.001	0.001	0.000	0.000	0.003	0.000	0.003	0.003	0.083
TOTAL	0.000	0.017	0.173	0.001	0.579	0.018	0.532	1.015	1.804	1.921	0.000*	31.451	3.126	99.99

* No weights as sample was accidentally destroyed

Table X

East Coast Survey : St Andrews (A)

Station No.	I	II	III	IV	V	VI	VII	VIII	X	XI	XII	XIII	XIV	
Traverse (distance in metres)	5	20	60	100	140	180	220	260	300	320	360	400	420	
Tidal level	~MHWS		~MHWN		~MTL				~MLWN					MLWS
Numbers per m^2														
Nemertini	–	–	64	64	16	–	–	–	16	–	–	–	16	
Sigalion mathildae	–	–	–	–	–	–	–	16	–	–	–	–	–	
Eteone longa	–	–	16	16	16	–	–	–	–	32	16	16	–	
Phyllodoce mucosa	–	–	–	–	–	–	–	–	–	–	16	–	–	
Phyllodocidae	–	–	–	–	–	–	–	–	–	–	–	–	16	
Nephtys cirrosa	–	–	16	–	96	176	224	320	128	448	336	528	368	
Nephtys hombergii	–	–	–	–	–	–	–	–	–	–	–	16	32	
Scolelepis squamata	–	–	64	96	64	80	–	–	–	–	–	–	–	
Spiophanes bombyx	–	–	–	–	–	160	96	192	176	240	320	352	224	
Spio filicornis	–	–	–	64	32	32	32	32	64	96	128	–	144	
Spio. sp. (Juvs)	48	–	–	–	16	272	–	–	–	–	–	–	49	
Magelona mirabilis	–	–	–	–	–	–	–	–	–	–	16	–	–	
Levinsenia gracilis	–	–	–	48	32	64	16	16	16	–	–	–	–	
Capitellidae	–	–	–	16	–	–	–	–	–	–	–	–	–	
Lanice conchilega	–	–	–	–	–	–	–	–	–	–	–	16	16	
Oligochaeta	1,808	336	144	–	32	64	16	–	–	–	–	–	–	
Pseudocuma gilsoni	–	–	–	–	–	–	–	16	–	32	176	160	176	
Bodotria pulchella	96	–	32	384	112	6,416	160	160	16	–	–	–	–	
Iphinoe trispinosa	–	–	–	–	–	–	–	–	–	–	16	–	–	
Bodotriidae	–	–	–	–	–	–	–	–	–	–	16	–	–	

Table X — Continued

Eurydice pulchra	—	80	—	—	—	—	—	—	—	—	—	—	—		
Bathyporeia elegans	—	—	—	—	—	—	32	128	96	288	192	48	336		
Bathyporeia guilliamsoniana	—	—	—	—	—	—	—	16	48	144	—	112	288		
Bathyporeia pelagica	—	—	—	—	16	—	—	—	—	—	—	—	—		
Bathyporeia pilosa	—	368	1,904	96	704	64	—	32	16	64	—	—	—		
Bathyporeia sarsi	—	—	400	48	64	—	—	—	—	—	—	—	—		
Bathyporeia sp.	—	—	—	—	—	—	—	—	—	—	—	—	32		
Perioculodes longimanus	—	—	—	—	—	—	—	—	—	—	—	—	16		
Pontocrates altamarinus	—	32	16	—	16	—	—	—	—	64	656	608	512		
Mysidacea	—	—	—	—	—	—	—	—	—	—	16	16	—		
Insect larvae	160	—	—	—	—	—	—	—	—	—	—	—	—		
Cyprina islandica	—	—	—	—	—	—	—	16	—	—	—	—	—		
Tellina tenuis	—	—	48	96	192	112	48	208	288	576	576	800	640		
Ensis sp.	—	—	—	—	—	—	16	—	16	—	—	—	—		
Donax vittatus	—	—	—	16	16	192	288	784	1,056	736	608	560	576		
TOTAL	2,112	816	2,704	944	1,424	7,632	928	1,936	1,936	2,720	3,088	3,232	3,440		
Traverse (distance in metres)	5	20	60	100	140	180	220	260	300	340	380	400	410	Mean	%
Weight (grammes) per m^2															
Polychaeta	0.000	0.000	0.315	0.851	0.415	1.466	0.903	1.651	0.826	0.959	1.304	2.162	1.297	0.935	9.026
Crustacea	0.011	0.130	1.051	0.075	0.120	0.094	0.024	0.049	0.040	0.139	0.174	0.245	0.212	0.182	1.757
Mollusca	0.000	0.000	0.373	1.104	1.315	2.536	3.863	11.273	22.164	17.273	21.168	17.512	21.145	9.210	99.908
Others	0.131	0.018	0.070	0.135	0.052	0.002	0.003	0.000	0.004	0.000	0.000	0.000	0.006	0.032	0.309
TOTAL	0.142	0.148	1.809	2.165	1.902	4.098	4.793	12.973	23.034	18.371	22.646	19.919	22.660	10.359	100.00
Large organisms															
Nephtys hombergii												1.776		0.137	
GRAND TOTAL	0.142	0.148	1.809	2.165	1.902	4.098	4.793	12.973	23.034	18.371	22.646	21.695	22.660	10.495	

Table XI

East Coast Survey : Gullane (A)

Station No.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	
Traverse (distance in metres)	5	15	35	60	90	110	140	160	190	210	240	260	290	305	
Tidal level	~MHWS			MHWN	MTL				~MLWN						~MLWS
Numbers per m^2															
Nemertini	–	16	–	32	64	336	48	–	–	–	–	32	–	16	
Eulalia viridis	–	–	–	–	–	–	–	–	–	–	16	48	–	–	
Eteone longa	–	–	–	32	–	32	16	16	32	16	48	32	–	32	
Phyllodoce maculata	–	–	–	–	–	–	–	–	16	–	–	–	–	16	
Syllidae	–	–	–	–	–	16	–	–	–	–	16	–	–	–	
Nephtys cirrosa	–	–	–	–	16	–	32	96	144	208	176	112	176	160	
Nephtys sp.	–	–	–	16	–	–	–	–	–	–	–	–	–	–	
Scolelepis squamata	–	–	112	672	112	784	80	–	–	–	–	–	–	–	
Spiophanes bombyx	–	–	–	–	–	–	–	32	32	–	64	80	112	80	
Polydora sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	16	
Spio filicornis	–	–	–	–	32	288	144	32	96	144	192	192	208	512	
Spio. sp. (Juvs)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
Scoloplos armiger	–	–	–	–	–	–	–	–	–	–	–	–	–	32	
Magelona mirabilis	–	–	–	–	–	–	–	–	–	–	–	–	64	–	
Paraonis fulgens	–	–	–	144	48	16	16	48	160	176	–	16	32	64	
Travisia forbesii	–	–	–	–	–	–	16	16	–	–	–	–	–	–	
Ophelia rathkei	–	–	–	640	144	48	–	–	–	–	–	–	–	–	
Capitellidae	–	–	–	16	128	–	–	16	–	–	16	64	64	–	
Lanice conchilega	–	–	–	–	–	–	–	–	–	–	–	16	64	–	
Oligochaeta	320	128	–	–	–	–	–	–	–	–	–	–	–	–	
Cumopsis goodsiri	–	–	–	256	304	320	80	400	80	16	–	–	–	–	
Pseudocuma gilsoni	–	–	–	–	–	–	–	–	–	80	64	80	96	144	

Table XI — Continued

Iphinoe trispinosa	—	—	—	—	—	—	—	—	—	—	—	16	16	16
Eurydice pulchra	—	384	16	—	48	32	—	—	—	—	—	—	—	—
Megaluropus agilis	—	—	—	—	—	—	—	—	—	—	—	64	32	16
Gammarus locusta	—	—	—	—	—	—	—	16	—	—	—	—	—	—
Bathyporeia elegans	—	—	—	—	—	16	288	—	416	144	288	32	64	64
Bathyporeia guilliamsoniana	—	—	—	—	—	—	—	—	386	720	1,456	560	1,456	1,024
Bathyporeia pelagica	—	—	—	—	48	—	—	—	—	—	—	—	—	—
Bathyporeia pilosa	—	—	—	—	—	80	48	—	—	32	—	32	—	—
Bathyporeia sarsi	—	—	—	80	—	—	—	—	—	—	—	—	—	—
Bathyporeia sp.	—	—	—	—	—	—	—	32	—	—	—	—	—	—
Haustorius arenarius	—	—	48	—	—	—	—	—	—	—	—	—	—	—
Urothoe pulchella	—	—	—	—	—	—	—	—	32	112	224	160	576	96
Perioculodes longimanus	—	—	—	—	—	—	—	—	—	—	—	—	16	64
Pontocrates altamarinus	—	—	—	64	80	—	128	32	128	32	304	864	176	288
Pontocrates arenarius	—	—	—	—	—	112	—	—	—	272	592	—	32	—
Atylus swammerdami	—	—	—	—	—	—	32	—	—	—	32	256	96	176
Atylus falcatus	—	—	—	—	—	—	—	—	—	—	—	—	—	48
Microprotopus maculatus	—	—	—	—	—	—	—	—	—	—	32	64	32	64
Tanaidae	—	—	—	—	—	16	16	80	64	48	16	16	64	96
Crangon crangon	—	—	—	—	—	—	—	—	16	—	—	32	16	16
Macropipus sp.	—	—	—	—	—	—	—	—	—	—	16	—	—	—
Insect larvae	48	—	—	—	—	—	—	—	—	—	—	—	—	—
Cerastoderma edule	—	—	—	—	—	—	—	—	—	—	—	16	—	—
Tellina tenuis	—	—	—	32	64	48	80	96	208	432	496	448	304	64
TOTAL	368	528	176	1,984	1,066	2,144	1,024	912	1,792	2,448	4,048	3,264	3,744	3,120

Table XI — Continued

Traverse (distance in metres)	5	15	35	60	90	110	140	160	190	210	240	260	290	305	Mean	%
Weight (grammes) per m^2																
Polychaeta	0.005	0.003	0.126	0.292	0.176	0.035	0.180	0.616	0.890	0.868	1.603	1.424	1.215	1.131	0.611	7.876
Crustacea	0.006	0.117	0.113	0.088	0.086	0.053	0.065	0.010	0.333	0.658	1.343	0.904	0.932	0.729	0.388	5.001
Mollusca	0.000	0.000	0.000	1.712	2.432	1.938	2.270	3.436	8.228	15.761	21.640	21.079	11.321	4.221	6.717	86.582
Others	0.010	0.004	0.000	0.054	0.004	0.127	0.002	0.000	0.000	0.000	0.000	0.033	0.000	0.352	0.042	0.541
TOTAL	0.021	0.124	0.239	2.136	2.698	2.153	2.517	4.062	9.451	17.287	24.586	23.440	13.468	6.433	7.758	100.00
Large organisms																
Travisia forbesii							0.846								0.060	
Crangon crangon													0.744		0.053	
Ammodytes sp.													3.201		0.229	
GRAND TOTAL	0.021	0.124	0.239	2.136	2.689	2.153	3.363	4.062	9.451	17.287	24.586	23.440	17.413	6.433	8.100	

Table XII

East Coast Survey : Belhaven (A)

Station No.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	
Traverse (distance in metres)	5	20	40	60	80	100	120	140	160	180	200	
Tidal level	~MHWS		~MHWN	~MTL					~MLWN			~MLWS
Numbers per m^2												
Nemertini	–	–	–	–	32	48	–	–	–	–	–	
Eulalia viridis	–	–	16	–	–	–	–	–	–	–	–	
Phyllodocidae	–	–	–	–	–	–	–	–	–	–	16	
Nephtys cirrosa	–	–	–	–	–	–	–	–	16	–	–	
Scolelepis squamata	–	–	48	16	16	32	144	64	96	96	48	
Oligochaeta	16	–	–	–	–	–	–	–	32	–	–	
Bodotriidae	–	–	–	–	–	–	–	–	16	–	–	
Eurydice pulchra	–	16	32	160	32	32	320	80	16	–	16	
Idotea linearis	–	–	–	–	–	–	–	–	–	–	16	
Idotea sp.	–	–	–	–	–	–	–	–	32	–	240	
Gammarus locusta	–	–	–	–	–	–	–	–	–	–	32	
Bathyporeia pelagica	–	–	16	1,408	32	–	–	–	–	–	–	
Haustorius arenarius	–	–	–	448	48	16	–	16	32	16	–	
Pontocrates altamarinus	–	–	–	–	–	–	–	–	592	112	464	
Pontocrates arenarius	–	16	368	80	720	256	–	16	272	–	–	
Atylus swammerdami	–	–	–	–	–	–	–	–	1,888	64	2,880	
Tellina tenuis	–	–	–	–	–	–	–	–	–	32	–	
Nudibranchia	–	–	–	–	–	–	–	–	–	–	16	
TOTAL	16	32	480	2,112	880	384	464	176	2,992	320	3,728	

Table XII — Continued

Traverse (distance in metres)	5	20	40	60	80	100	120	140	160	180	200	Mean	%
Weight (grammes) per m^2													
Polychaeta	0.001	0.000	0.017	0.021	0.000	0.012	0.397	0.743	0.057	0.094	0.022	0.124	37.920
Crustacea	0.000	0.022	0.090	0.602	0.071	0.020	0.242	0.107	0.265	0.212	0.326	0.178	54.434
Mollusca	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.214	0.002	0.020	6.116
Others	0.000	0.000	0.000	0.000	0.018	0.031	0.000	0.000	0.001	0.000	0.000	0.005	1.529
GRAND TOTAL	0.001	0.022	0.107	0.623	0.089	0.063	0.639	0.850	0.323	0.520	0.350	0.327	99.999

Table XIII

Fauna list and distribution. Numbers 1—11 refer to the beaches shown in Figure 1

Anthozoa	4
Nemertini	1, 2, 3, 4, 5, 7, 8, 9, 10, 11
Sigalion mathildae Audouin and Milne-Edwards	9
Aphroditae	8
Eulalia viridis (O.F. Müller)	3, 8, 10, 11
Eteone longa (Fabricius)	3, 4, 7, 9, 10
Phyllodoce mucosa Oersted	9
Phyllodoce maculata (L.)	10
Phyllodocidae	7, 9, 11
Streptosyllis websteri Southern	3
Autolytus sp.	8
Syllidae	3, 8, 10
Nereis sp.	3
Nephyts caeca (Fabricius)	8
Nephtys cirrosa Ehlers	2, 3, 4, 7, 8, 9, 10, 11
Nephyts hombergii Oersted	9
Nephtys sp.	10
Scolelepis squamata (O.F. Müller)	2, 3, 4, 5, 6, 7, 8, 9, 10, 11
Spiophanes bombyx (Claparede)	3, 4, 8, 9, 10
Malacoceros fuliginosa (Claparede)	5, 8
Spio filicornis (O.F. Muller)	3, 7, 8, 9, 10
Pygospio elegans Claparede	3, 4
Polydora sp.	10
Spio sp.	3, 8, 9, 10
Scoloplos armiger (O.F. Müller)	4, 10
Magelona mirabilis (Johnson)	9, 10
Paraonis fulgens (Levinsen)	1, 2, 3, 4, 5, 7, 8, 10
Paraonis sp.	8
Levinsinia gracilis (Tauber)	9
Chaetozone setosa Malmgren	3
Cirratulidae	8
Travisia forbesii Johnson	10
Ophelia rathkei McIntosh	3, 4, 7, 10
Capitella capitata (Frabricius)	3, 4
Capitellidae	8, 9, 10
Arenicola marina (L.)	4
Lanice conchilega (Pallas)	8, 9, 10
Oligochaeta	1, 2, 3, 4, 5, 6, 7, 9, 10, 11
Cumopsis goodsiri (Benedon)	2, 4, 8, 10
Cumopsis longipes (Dohrn)	8
Pseudocuma gilsoni Bacescu	7, 8, 9, 10
Bodotria pulchella (Sars)	3, 9
Iphinoe trispinosa (Goodsir)	9, 10
Bodotriidae	9, 11
Eurydice pulchra (Sars)	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
Idotea baltica (Pallas)	7
Idotea pelagica Leach	8
Idotea linearis (L.)	11
Idotea sp.	7, 11
Talitrus saltator (Montagu)	1, 2, 3, 4, 6, 7, 8
Gammarus locusta (L.)	7, 8, 10, 11
Megaluropus agilis Hoek	10
Bathyporeia elegans Watkin	1, 2 3, 4, 7, 8, 9, 10
Bathyporeia guilliamsoniana (Bate)	7, 8, 9, 10
Bathyporeia pelagica (Bate)	1, 2, 4, 5, 6, 7, 9, 10, 11
Bathyporeia pilosa Lindstrom	1, 2, 3, 4, 6, 7, 8, 9, 10
Bathyporeia sarsi Watkin	3, 4, 9, 10
Bathyporeia sp.	9, 10
Haustorius arenarius (Slabber)	1, 3, 4, 6, 7, 8, 10, 11
Urothoe pulchella (Costa)	10
Stenothoe monoculoides (Montagu)	5
Perioculodes longimanus (Bate and Westwood)	7, 9, 10
Pontocrates altamarinus (Bate and Westwood)	5, 6, 7, 8, 9, 10, 11
Pontocrates arenarius (Bate)	1, 2, 3, 4, 5, 6, 7, 8, 10, 11

Table XIII – Continued

Atylus falcutus Metzger	10
Atylus swammerdami (Milne-Edwards)	7, 8, 10, 11
Microprotopus maculatus Norman	8, 10
Tanaidae	10
Gastrosaccus spinifer (Goes)	2
Schistomysis spiritus (Norman)	5
Mysidacea	9
Crangon crangon (L.)	10
Macropipus sp.	10
Insect Larvae	9, 10
Rissoa sp.	3, 5
Mytilus edulis L.	2, 6, 7, 8
Cyprina islandica (L.)	7, 9
Cerastoderma edule L.	3, 10
Macoma balthica (L.)	3
Tellina fabula Gmelin	8, 10
Tellina tenuis da Costa	2, 3, 4, 8, 9, 10, 11
Tellinidae	3
Ensis sp.	9, 10
Donax vittatus (da Costa)	4, 9, 10
Nudibranchiata	11

Table XIV

Summary of beaches

A. Sheltered

	Particle size range $\bar{x}$ dia (μm)	Beach extent (metres)	$\bar{x}$ C ($\mu g\ g^{-1}$ Sed)	$\bar{x}$ Chl a ($\mu g\ g^{-1}$ Sed)	$\bar{x}$ Biomass ($g\ m^{-2}$)	$\bar{x}$ Abundance (nos. per m^2)	P	C	M	O	Total
Nairn	194–218 204	270	339	0.66	1.176	864	15	8	5	2	30
Burghead	181–222 200	175	366	1.19	1.625	1,353	10	9	2	3	24
Tentsmuir	189–235 212	197	284	0.26	3.126	695	16	15	3	1	35
St Andrews	149–194 158	450	519	0.48	10.359	2,531	14	14	4	3	35
Gullane	156–237 233	300	618	1.09	8.100	1,901	18	24	2	3	47
Range	158–233	–	284–618	0.26–1.19	–	–	–	–	–	-	
Overall x	x : 201		x : 425	x : 0.73							

Table XIV — Continued

B. Exposed

	Particle size range $\bar{x}$ dia (μm)	Beach extent (metres)	$\bar{x}$ C ($\mu g\ g^{-1}$ Sed)	$\bar{x}$ Chl a ($\mu g\ g^{-1}$ Sed)	$\bar{x}$ Biomass ($g\ m^{-2}$)	$\bar{x}$ Abundance (nos. per m^2)	P	C	M	O	Total
Sinclair's Bay	227–316 255	100	388	0.52	0.058	113	1	6	–	2	9
Dornoch	198–273 233	120	444	0.80	0.220	443	3	8	2	2	15
Fraserburgh	227–269 245	150	780	2.12	0.241	165	3	6	1	2	12
Rattray	238–318 280	120	395	0.65	0.506	452	1	7	1	1	10
Lunan Bay	216–286 254	272	258	0.26	1.475*	519*	7	15	2	2	26
Belhaven	250–382 308	200	370	0.24	0.327	1,053	4	10	1	3	18
Range	233–308	–	258–780	0.24–2.12	–	–	–	–	–	–	–
Overall $\bar{x}$	$\bar{x}$: 315		$\bar{x}$: 439	$\bar{x}$: 0.76							

* Large concentrations of *Haustorius*

Number of species: P = Polychaeta; C = Crustacea; M = Mollusca; O = Other

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